SCIENCE

15 January 1960
Vol. 131, No. 3394

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

the laboratory microscope which fulfills research requirements

For photomicrography and simultaneous observation, binocular photo tube "FS" is available at an additional charge of $50.00.

Model S 48/76
. . . . $874.00

the new LEITZ LABOLUX IIIa

The Leitz Labolux IIIa is a new laboratory microscope with built-in illumination and the famous Labolux ball-bearing focusing control, which combines both coarse and fine focusing in a single knob. Available with a wide variety of accessories, the Labolux IIIa is recommended for all routine laboratory work and, in addition, can be equipped to fulfill the most exacting research.

A variety of interchangeable tubes is available: monocular, binocular or trinocular (binocular viewing plus photo tube for photomicrography). Tubes can be rotated 360° so that the Labolux IIIa may be faced away from the observer, for increased accessibility to all controls and to the object stage, and to make "conference-viewing" by two consultants more convenient.

Among the condensers available are the Abbe type, the Berek 2-diaphragm condenser, and condensers for phase contrast and dark field observations. The Labolux IIIa is readily adapted to fluorescence microscopy by addition of the Leitz fluorescence accessories. The large stand, in a new contemporary design, is constructed for a lifetime of use with fatigue-free operation and precision performance. All controls, including the knobs for the mechanical stage, are in a low convenient position. High-power objectives have spring-loaded mounts for prevention of damage to lenses and slides.

LABOLUX IIIa, Model S 25/95

• inclined binocular tube S with knurled knob to adjust for proper interpupillary distance • built-in mechanical stage #25 • two-lens condenser #95 • substage unit with rack and pinion focusing accepts sleeve-type condensers • quadruple nosepiece with achromats 3.5X, 10X, 45X and 100X oil immersion, the last two having spring-loaded mounts • paired 10X wide-field eyepieces • horizontal carrying case • 3-step transformer, 6 V, 2.5 Amp. **$734.00**

For literature and/or a personal demonstration in your laboratory, write:

Leitz

E. LEITZ, INC., 468 FOURTH AVENUE, NEW YORK 16, N.Y.
Distributors of the world-famous products of Ernst Leitz G. m. b. H., Wetzlar, Germany—Ernst Leitz Canada Ltd.
LEICA CAMERAS · LENSES · MICROSCOPES · BINOCULARS

32959

SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Second-class postage paid at Washington, D.C., and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

IF YOU HAVE A NEED FOR SPECIAL INSTRUMENTATION... PERKIN-ELMER CAN FILL IT

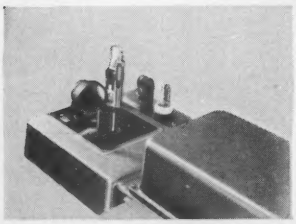
P-E's Special Engineering Sales Group develops instruments for ultra-precise chemical analysis or physical measurements

Perkin-Elmer's "building-block" concept makes possible the combination of many standard P-E optical and electronic units in a single instrument for special projects in chemical or physical research.

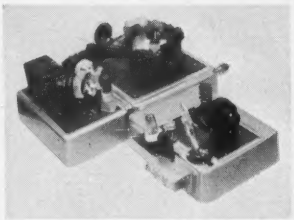
If your project requires the creation of special-purpose accessories or even the design and construction of a completely new system, the Special Engineering Sales Group is well prepared to undertake the job. It is backed by Perkin-Elmer's total experience and facilities in the field of instrumentation.

Here are a few of P-E's building-block units and instruments which have been assembled from them.

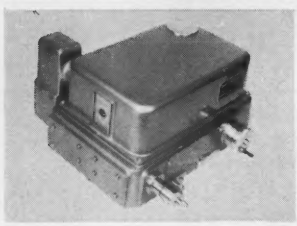
BUILDING BLOCK AND SPECIAL ENGINEERING UNITS



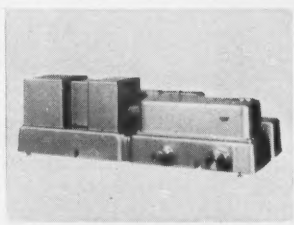
SOURCES: A variety of assemblies to provide globar, hydrogen, tungsten, or xenon sources, or any combination. Source focussing optics included; special choppers are also available.



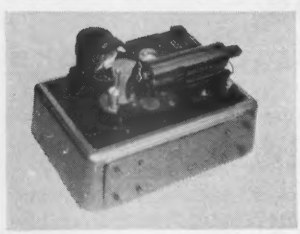
RAPID-SCAN SPECTROMETERS: Utilizing oscillographic or galvanometric read-out. These P-E building-block instruments analyze fast-moving reactions by scanning infrared wavelengths at very high rates. A variety of sources and detectors may be used. Scanning frequencies range from 2.5 to 180 spectra/second.



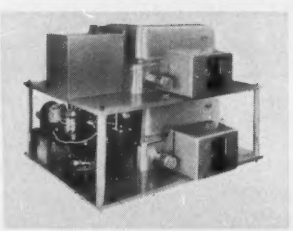
MONOCHROMATORS: Single-beam prism and grating monochromators in both single and double-pass modes. Double-pass instrument has chopper as standard equipment. Single-pass monochromators are used in single and double-beam systems; they are also used where DC radiation is required, or where chopping before the sample is essential.



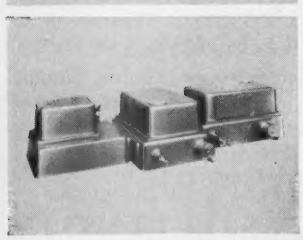
FAR INFRARED GRATING SPECTROMETER: Operating in the region from 25 to 150 microns, the P-E far infrared instrument utilizes three gratings and associated filters to cover this range. The monochromator provides the ability to scan in linear wavenumbers, affords maximum slit opening of 10 mm. A Golay detector with a diamond window is used in this region.



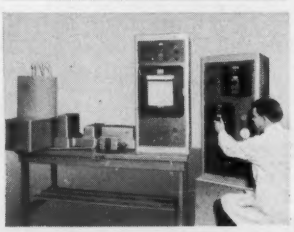
DETECTORS: Individually or in assemblies, lead sulfide, photomultiplier, Golay, thermocouple and photoconductive detectors, with associated focussing and exit optics Switching systems to change multi ple detectors are also provided.



SPECTROPHOTOFLUORIMETER: Fluorescent materials, excited by energy at one wavelength, emit light at another (usually longer) wavelength. Perkin-Elmer's Spectrophotofluorimeter is a device for measuring this phenomenon. Constant linear energy levels of excitation are assured as the excitation wavelength is scanned.



GRATING UNITS: Fore-prism grating units for separating orders when used with grating monochromators, thus affording the highest resolution possible. Combinations are available to cover wavelength range from UV to the far infrared.



DIFFUSE REFLECTANCE ATTACHMENT: A building-block utilization of the heated hohlraum technique, this attachment for the Perkin-Elmer Model 13 measures absolute spectral reflectance and emissivity in the range from 2 to 15 microns. KBr optics increase range to 20 microns.

P-E's Special Engineering Sales Group invites inquiries from scientists whose research problems involve measurements too complex or precise for standard instruments. Perkin-Elmer Corp., 910 Main Ave., Norwalk, Conn.

INSTRUMENT DIVISION
Perkin-Elmer *Corporation*
NORWALK, CONNECTICUT

15 January 1960, Volume 131, Number 3394

SCIENCE

Cover

This Mach Zehnder interferometer pattern shows a refractive index homogeneity of approximately three parts per million in barium flint optical glass. The pattern is in a disk 12 inches in diameter and 2¼ inches thick. It was made for use by the Perkin-Elmer Corp. in aerial camera lenses. [Corning Glass Works]

One of a series

Resolving the driver-car-road complex

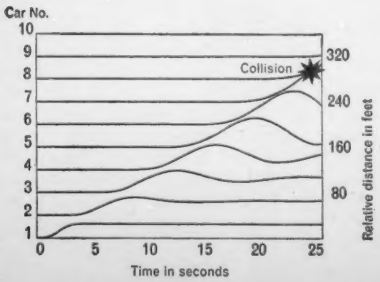
The manner in which vehicles follow each other on a highway is a current subject of theoretical investigation at the General Motors Research Laboratories. These studies in traffic dynamics, coupled with controlled experiments, are leading to new "follow-the-leader" models of vehicle interaction.

For example, conditions have been derived for the stability of a chain of moving vehicles when the velocity of the lead car suddenly changes – a type of perturbation that has caused multiple collisions on modern superhighways. Theoretical analysis shows that the motion of a chain of cars *can be stable* when a driver accelerates in proportion to the relative velocity between his car and the car ahead. The motion is always unstable when the acceleration is proportional only to the relative distance between cars. Experimentally, GM Research scientists found that a driver does react mainly to relative velocity rather than to relative distance, with a sensitivity of reaction that increases with decreasing distance.

Traffic dynamics research such as this is adding to our understanding of intricate traffic problems – what causes them, how they can best be resolved. The study is an example of the ways GM Research works to make transportation of the future more efficient and safe.

General Motors Research Laboratories

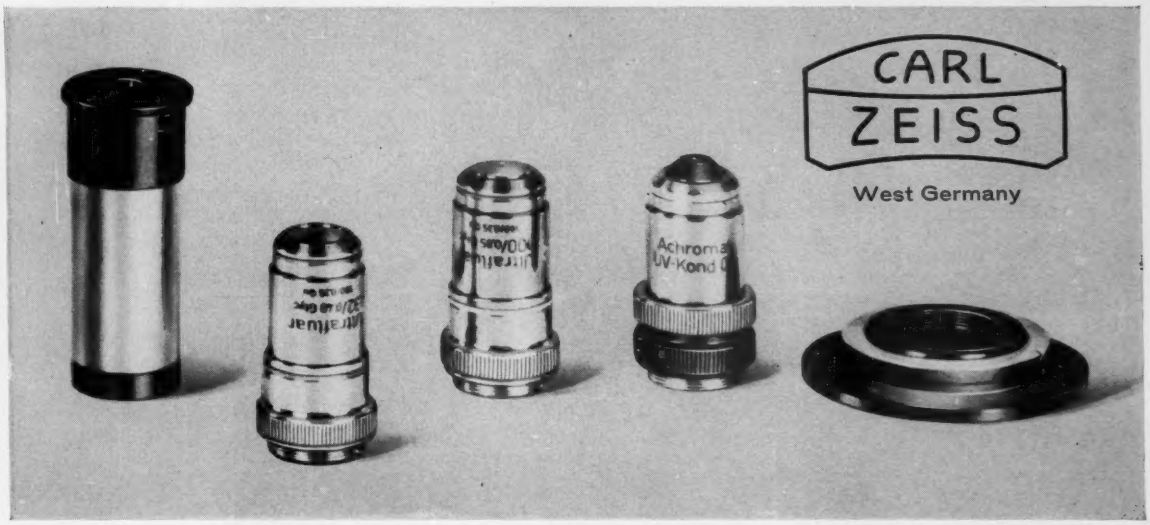
Warren, Michigan



Relative positions of 10 hypothetical cars after lead car goes through maneuver. Amplitude of instability increases, resulting in a collision between 7th and 8th cars.

Announcing
NEWLY DEVELOPED OPTICS

Corrected simultaneously for any wave-length from ultra-violet up to the near infra-red (240 m to 700 m).



Shown in picture above:

UV Projective K 10:1

Ultrafluar 32/0.40
(glycerine immersion)

Ultrafluar 100/0.85
(glycerine immersion)

Achromatic UV Condenser
0.8 with iris diaphragm

They offer for the first time these great advantages:

1 Elimination of the restricted application of monochromatic objectives and the short-comings of mirror objectives.

2 No limitation in wave-length, therefore ideal for new methods of cell structure studies, photomicrography and micro-absorption measurements depending upon the wave-length.

3 Independence from light sources producing particular monochromatic light.

4 A once visually focused image in the visible part of the spectrum need not be refocused when changing over to ultra-violet radiation.

5 Adaptability to any standard type microscope.

Write for information

CARL ZEISS, INC.

485 FIFTH AVENUE, NEW YORK 17, N. Y.

COMPLETE SERVICE FACILITIES

*More Beckman DK's are used in more applications than all other ultraviolet recording spectrophotometers combined...*Why? Because the DK is a laboratory workhorse. ⌘ Because it's simple to use and automatic. ⌘ Because a complete line of accessories and a measurement range of 185 to 3500 mμ make it versatile in use. ⌘ Because it's the lowest priced recording spectrophotometer available. ⌘ And because the DK is sold and serviced from over 75 locations throughout the United States. For detailed specifications on this outstanding Recording Spectrophotometer, contact your convenient Beckman DK dealer or write us for Data File 38-3-03

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road, Fullerton, California

Beckman has BIG news for you at the Pittsburgh Symposium.

It's a Fact: **For infrared spectroscopy, the low-cost Beckman IR-5 gives automatic, high resolution analyses in 16 minutes.**

15 January 1960, Volume 131, Number 3394

SCIENCE

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. The joint journal is published in the SCIENCE format. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125**, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address label from a recent issue. Give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage. 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

The Doctors Disagree

One source of happy expectation behind the American-British-Soviet negotiations on the cessation of nuclear tests was that it would be easier for technical experts to agree on scientific truth than for diplomats to agree on political measures. The hope was that once the experts established what was technically feasible in the way of discouraging any country from conducting secret tests, the diplomats could set about the task of turning a scientific possibility into a political reality. In the summer of 1958 a conference of experts did succeed in agreeing on an inspection system, which, on the basis of evidence then available, was thought to provide adequate safeguards. Unfortunately, a conference of experts in 1959 proved less successful. Running from 25 November through 18 December, the conference produced agreement on possible improvements in instrumentation, but left other important questions unresolved.

The American and Soviet delegations each have their own ideas about who is wrong in these disputes, and any expert in one of the appropriate fields who will take the trouble to read the verbatim records of the conference, or the separate briefs filed at the end of the conference, can make his own attempt at scientific objectivity. A test of objectivity, however, is also open to the non-expert reader. He can consider which of the two sides displayed the greater tendency to stray from the scientific issues at hand. For scientists not only may find it difficult to reach agreement, but they are just as prone as other men to bring in irrelevant arguments to discredit their opponents.

A typical example of straying from the issues at hand occurred in what was probably the most important area of dispute, the interpretation to be put upon the new seismic data from the American Hardtack experiments. The Americans claimed that the Hardtack experiments show that the 1958 conference of experts was too optimistic about the effectiveness of the control system it recommended. Specifically, the Americans claimed that the direction of first motion of a seismic needle is less effective in identifying seismic disturbances as earthquakes than had previously been thought. Since the instrumental set-up used in the Hardtack experiments was not precisely the same as that recommended by the 1958 conference, the Americans also offered a demonstration that the set-up was fully adequate for the purposes of testing the method of first motion. The Soviets were free to question this demonstration, and they did, but somehow time and time again they came back to the point that the Hardtack instrumental set-up after all *was* different. This matter of difference is irrelevant—the question is whether the American demonstration of the full adequacy of the set-up is valid—but the fact that there is a difference could be made to leave the impression that the Americans were trying to palm off unreliable data.

Following the failure of the 1959 conference to reach agreement, President Eisenhower declared on 29 December that the United States would not extend its 14-month moratorium on testing beyond the expiration date of 31 December, but that any future tests would be announced in advance. No immediate American tests are expected. On 3 January the Moscow radio broadcast a pledge by Premier Khrushchev that the Soviet Union would not explode nuclear weapons unless the West did. Britain's policy is not to resume testing so long as "useful" negotiations continue. Political talks were resumed again on 12 January, and it may be that the conference of experts did serve a useful purpose. Prior to the conference it seems that the Soviet scientists not only disagreed with the American scientists, but did not really understand the new material that troubled them. Now the Soviets understand, and if what bothers American scientists is valid, it may come to bother Soviet scientists too.—J.T.

The taming of the spectrum

Do you need pure light of single wavelengths? More and more people do. In science and technology. In applications from cancer research to irradiation to missile guidance. Here are three ways Bausch & Lomb optical competence is filling the need.

- **B&L INTERFERENCE FILTERS** transmit light of specific wavelengths. Wide standard stock, from near ultra-violet (340mμ) to near infra-red (1200mμ).
- **B&L CERTIFIED-PRECISION GRATINGS** split light into all its component wavelengths. You get clearer separation between spectral lines than by any other means.
- **B&L GRATING MONOCHROMATORS** let you dial pure intense light of any wavelength you want. Easy as tuning your radio!

BAUSCH & LOMB

SINCE 1853

BAUSCH & LOMB OPTICAL CO.
75901 Bausch St., Rochester 2, N. Y.

Please send

- ☐ Interference Filter Catalog D-248
- ☐ Gratings Catalog D-261
- ☐ Monochromator Catalog D-259

Name .....

Title .....

Professional Address .....

.....

15 January 1960, Volume 131, Number 3394 SCIENCE

Structure of West Antarctica

The results of U.S. IGY oversnow traverses reveal the nature of a large portion of ice-covered Antarctica.

C. R. Bentley, A. P. Crary, N. A. Ostenso, E. C. Thiel

As part of its program for the International Geophysical Year and the IGY's successor, International Geophysical Cooperation, the United States is conducting an extensive traverse program in Antarctica. Seven major oversnow traverses, supplemented by several shorter trips and one airborne traverse, have thus far covered over 12,000 kilometers on the Filchner and Ross ice shelves, Marie Byrd Land, the Ellsworth highland, and the Victoria Land plateau of eastern Antarctica (Fig. 1). The scientific program of these traverses comprised glaciological investigations of the upper layers of the icecap and seismic, gravity, magnetic, and elevation studies to determine ice thickness, the physical characteristics of the icecap, and the nature of the rock floor beneath the ice. From this work a fairly clear outline of the structure of West Antarctica has now emerged.

Methods of Operation

Although there have been differences in the methods employed by the various traverse parties (*1*), the over-all procedure has been the same for all. Three Tucker Sno-cats were normally used by each party. The parties generally traveled 50 kilometers every day, stopping at regular intervals to read the gravimeter, the magnetometer, and the altimeters, and spent the alternate days making seismic and glaciological investigations.

The primary seismic measurements at each station were those of ice thickness and, on the floating ice shelves, of the depth of the water beneath the ice, made by reflection shooting. The travel time of the compressional wave echo served to locate the rock surface; in order to determine the thickness of floating ice, several methods utilizing multiple travel paths or shear waves, or both, were employed.

In addition to the reflection sounding, many short refraction profiles were shot to give a detailed determination of velocity variations in near-surface snow and ice. Travel times for both compressional and shear waves were recorded. This work was done to provide a comparison of the seismic wave velocities with the other physical properties of the ice, and to obtain corrections to the bottom-echo time for the low velocities near the surface.

At a number of locations long refraction profiles were shot to obtain information about the seismic velocities throughout the icecap and in the underlying rock. Both vertically and horizontally oriented geophones were used in order to record all possible phases. Shots were fired at distances up to 22 kilometers with charges as large as 870 pounds. These long refraction profiles provided, along with other valuable data, the wave velocities used for computing ice thickness.

Equipment

All traverses used the 24-trace Texas Instruments 7000B portable seismograph system with a basic frequency range of 5 to 500 cycles per second and with a selection of gain, filter, mixing, and automatic-gain-control settings that provided a large number of operating characteristics. Automatic gain control was very rarely used, and mixing only occasionally, with no appreciable improvement in the records. The parties were also equipped with two Vector geophone cables each having 12 takeouts at 30-meter intervals, and with a variety of geophones for measuring all components of motion over a wide frequency range.

Gravity values on the oversnow traverses were obtained with Frost gravimeters provided by Columbia University and the University of Wisconsin. A Worden geodetic meter was used at the airborne stations. The three Frost meters had been used for several years prior to the IGY, so their behavior was well known. Although the Worden meter was relatively new, and there was still some uncertainty about its drift rate, errors were minimized by the fact that ties back to the base at Byrd station were usually completed within 10 hours.

Magnetic measurements were made with an Arvela vertical-component magnetometer having a reading accuracy of about 10 gammas. Surface elevations were obtained with Wallace and Tiernan altimeters. A leapfrog or modified leapfrog method was used whenever travel conditions permitted.

Data Reduction

As has been discussed elsewhere (*2*), a low-velocity ice layer was discovered at the base of the icecap in Marie Byrd Land. Uncertainty about the thickness

Dr. Bentley, Mr. Ostenso, and Dr. Thiel are affiliated with the Antarctic Research Center of the University of Wisconsin, Madison. Dr. Crary is on the staff of the Geophysical Research Directorate, Air Force Cambridge Research Center, and is chief scientist of the Antarctic Research Program of the National Science Foundation.

(or even the existence, in many places) of this layer and its wave-propagation characteristics diminishes the accuracy with which echo time can be converted into ice-thickness values. The maximum error in total ice thickness which would result from improper allowance for this layer is estimated to be 40 meters. The error in relative thickness between two neighboring stations would be considerably less than this but is difficult to reckon, owing to lack of information concerning the variability of the basal layer from place to place.

The gravity values measured between the seismic stations were used to provide detail in the topographic profile. Free-air gravity anomalies were used to compute ice thickness, although, with reflection shooting providing absolute depth control every 50 kilometers, Bouguer anomalies would have produced negligibly different results. The densities used for this interpolation were 0.9 gm/cm^3 for ice, 1.03 gm/cm^3 for sea water, and 2.67 gm/cm^3 for rock. From a consideration of the various sources of error, of which uncertainty about elevation is by far the greatest, the over-all accuracy of the computed gravity anomalies is estimated to be ± 10 milligals.

Considerable difficulty was experienced in trying to correct magnetic observations made by the traverse parties. The party was generally too far from a permanent station to permit effective control by means of the base-station magnetographs. For this reason the magnetic data have been used only to obtain a regional gradient and to give the general magnetic character of the basement rock.

Surface heights usually were calculated by the summation of elevation intervals measured between traverse vehicles as they traveled several kilometers apart. The normal corrections for temperature and humidity were applied, and also a correction for pressure gradient between vehicles, as estimated from the wind velocity two meters above the surface (*3*). The estimated maximum error of elevation determination at all traverse stations is 20 meters relative to the base station. This error decreases with decreasing distance between the field station and the base station. Another source of error in Marie Byrd Land elevations is uncertainty in the elevation of the base station, Byrd station. This uncertainty is estimated by the U.S. Weather Bureau to be 15 meters (*4*).

Ice-Surface Topography

The ice-surface contour map of the portion of West Antarctica which has been covered to date is shown in Fig. 2. Data from a short traverse to the Executive Committee Range conducted in February and March of 1959 were generously provided by William Chapman and have been used in constructing this map.

Two definite high areas are apparent, one in the east between the Sentinel and Horlick mountains and the other in the northwest in the vicinity of the Executive Committee Range. Between these areas is a saddle indicating converging movement of the ice from the high regions and outflow to the west and north. It is interesting to note the decided asymmetry of the icecap about the line between the Sentinel and Horlick mountains. To the east, where there are no obstacles, the ice surface slopes down rapidly to the Filchner Ice Shelf; to the west the converging flow has produced a relatively flat surface over the broad reaches of the interior of West Antarctica. Thus, the ice-surface contours suggest that the present ice sheet originated as separate icecaps in two mountainous areas, the Executive Committee Range and the area between the Sentinel and Horlick mountains, and that these two caps converged across the intervening low region.

Subglacial Topography

As the first step in the construction of a contour map of the subglacial rock topography, seismic reflection, gravity, and altimetry results were combined so that cross sections of the icecap along the various traverse routes could be drawn. Lines of mean depth were then estimated by eye in such a way as roughly to average out features less than 80 kilometers in extent. The resulting map is shown in Fig. 3. Ice-covered areas exhibiting a rock surface below sea level are hachured; the boundary of this zone was estimated where no direct evidence was available.

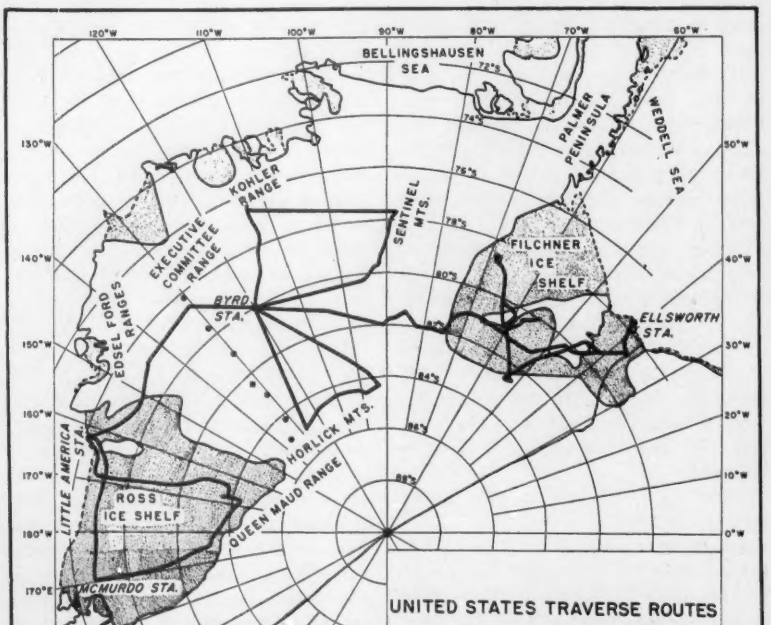


Fig. 1. Traverse routes in West Antarctica.

In considering the rock elevation beneath the thick, grounded ice of Marie Byrd Land, it should be remembered that the weight of the overlying ice has depressed the land surface on the order of 500 meters (up to 1000 meters in the deepest part of the central basin). Thus, sea level before the growth of the ice in western Antarctica should be fairly well represented by the −500-meter contour.

From this map it may be seen that, with the exception of Roosevelt Island near Little America station and the high spot centered around latitude 83°S, longitude 105°W, the region between the Sentinel, Horlick, and Queen Maud mountains to the south and the Kohler, Executive Committee, and Edsel Ford ranges to the north, is below sea level, most of it at least 500 meters below. Conspicuous within this region between Byrd station and the Sentinel Mountains is the deep basin whose maximum depth is more than 2500 meters. This basin, although becoming gradually shallower, broadens to the northeast and probably continues for some distance beyond the area surveyed. From this trend we infer that the rock surface below sea level extends northeast to the ocean, forming a vast channel across West Antarctica between the Ross and Bellingshausen seas.

Although, as previously mentioned, it was not possible to correct the magnetic data for temporal variations, a considerable change in their general character along the route appeared. North of the channel area the magnetic profile exhibits large variations which correlate qualitatively quite well with the variations in rock level. In the basin and along the Sentinel Mountains the variations are much smaller and show no relation to the subglacial topography. (Magnetic data from the Horlick Mountain region are not yet available.) The smoothest part of the magnetic curve is in fact found where the rock surface is the roughest. The magnetic evidence may therefore be taken to indicate that the rock immediately below the ice north of the channel possesses a relatively high magnetic susceptibility, whereas rock types with lower susceptibility exist under the basin and in the Sentinel Mountains.

Such a conclusion is in agreement with the limited geological evidence which is available. Rock samples collected just south of the Kohler Range and (during March 1959) from the Executive Committee Range by the Byrd traverse group now in Antarctica (*5*), as well as the shapes of the peaks themselves, indicate that these mountains are of volcanic origin. On the other hand, low-grade metamorphics were found in the foothills of the Sentinel Mountains (the main range was not reached) and in other nunataks on that traverse; visits to the Horlick Mountains and to neighboring peaks yielded samples of granite and sedimentary rocks (*6*). Granite and metasediments are known to occur along the coast in the Edsel Ford Range, but nowhere else northwest of Byrd station (*7*).

Long refraction shooting has given the wave velocities in the rock beneath the ice at several places. A value of 5.2 km/sec was found in the foothills of the Sentinel Mountains and on the eastern edge of the basin, whereas a significantly lower velocity of 4.3 km/sec was recorded at Byrd and Little America stations, both of which are within the channel.

Several lines of evidence are thus in agreement in indicating that the channel marks the dividing line between geologic provinces, separating the volcanic mountains on the north from the folded, metamorphic mountains of the Sentinel group to the east and the sedimentary, block-faulted Horlick group to the south.

The Filchner Ice Shelf reaches much farther inland than had been suspected prior to the IGY (*8*). It extends south for 650 kilometers from the ice front and has an area of approximately 330,000 square kilometers (exclusive of the large island) as compared with 540,000 square kilometers for the Ross Ice Shelf. This discovery, together with that of the large channel in Marie Byrd Land, has disclosed that West Antarctica consists, in fact, of a great southward extension of the Palmer Peninsula together with a mountainous island, or, more probably, series of islands, comprising the coastal ranges of Marie Byrd Land. Taylor (*9*) in 1930 postulated the existence of a downwarp or trough between the Ross and Weddell seas, and such a feature has been the subject of considerable

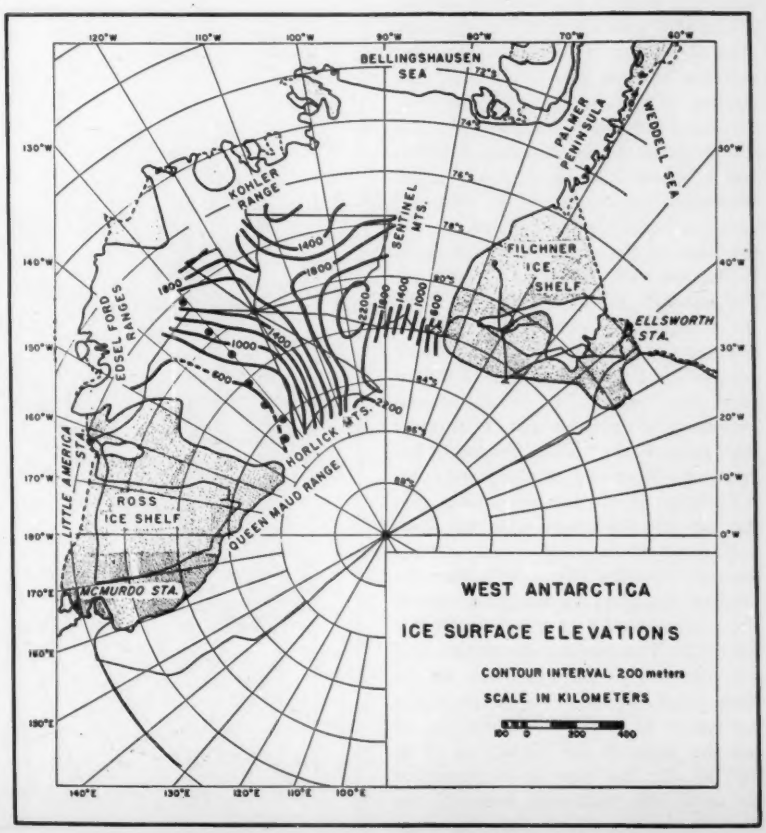


Fig. 2. Ice surface elevations in West Antarctica.

speculation since that time. In view of this it is worth while to consider briefly the continuity of the peninsula.

Although the area between the Sentinel Mountains and the base of the Palmer Peninsula has been seen only from a distance, some mountains are known to exist within the area, and there is at present no reason to doubt that there is a continuous land area across this region. From the traverse work it is virtually certain that the mountain chain continues unbroken to latitude 82°S. Between latitudes 82° and 84°S, along the 90°W meridian, mountains have been reported (see, for example, the 1958 edition of the map of Antarctica prepared by the American Geographical Society), but their positions are very uncertain, and in view of other evidence given below, their existence cannot be taken as proof of the extension of the peninsula to the Horlick Mountains.

A trough with depths greater than 1000 meters below sea level can be seen to extend from the edge of the Filchner Ice Shelf, near Ellsworth station, to the mountains at longitude 85°W. A trough is also shown along the entire western and southern boundary of the Ross Ice Shelf. In between, there is no clear evidence of a similar decrease in rock elevation toward the Horlick Mountains although the rock surface is well below sea level all along the mountain front. A trough-like feature is shown from the central Horlick Mountains to 82°S, 95°W, but this could as easily be attributed to the existence of the small mountain group to the northwest as to any trough associated with the Horlick front. From the topographic information it is not possible at present to determine whether the Sentinel and Horlick mountains are joined by a continuous mountain chain, although it is clear that there is no broad connection between the Ross and Weddell seas.

Geological evidence establishes that the Horlick Mountains are unmistakably a part of the antarctic horst, which appears to extend all the way from the western boundary of the Ross Sea to the eastern border of the Filchner Ice Shelf (*6*). The Sentinel Mountains and the nunataks to the southwest, on the other hand, appear to be similar to the mountains of the Palmer Peninsula, as are the peaks in the vicinity of 83°S, 105°W. On this basis it is reasonable to draw the boundary between the fault-block mountains and the geosynclinal, folded mountains just north of the Horlick Mountains (*10*). Therefore, the geological evidence tends to support the hypothesis of a topographic low expressing the break between folded mountains of the Palmer Peninsula type and the block-faulted mountains of the antarctic horst. However, even if this feature exists, it would be in no way comparable to the major channel between the Ross and Bellingshausen seas. An airborne traverse party under Thiel is now studying the area and should provide the data needed to resolve the question of the existence of such a trough.

Crustal Structure

The gravity results can be used not only to provide detail in the ice-thickness profile but also to obtain a rough picture of the crustal structure of West Antarctica. To remove variations due to changes of minor extent in the rock level, the free-air gravity anomalies have been averaged over 100-kilometer intervals. The resulting anomaly pattern shows that, by and large, West Antarctica is in isostatic balance, the average anomalies ranging between −52 and +49 milligals. The over-all mean anomaly of −9 milligals is not significant when compared with the root mean square deviation from the mean of ±23 milligals.

The discovery that most of the land surface under the ice of West Antarctica lies well below sea level has made it of particular interest to estimate crustal thickness in the area. This has been done by using empirical relations deduced by Woollard (*11*) which relate the elevation of the Mohorovičić discontinuity (*M*) to surface elevations and Bouguer gravity anomalies, respectively. These curves are based upon all available depths to *M* in North America and the associated Bouguer anomalies and surface elevations. Scientists of the U.S.S.R. have recently established the same type of relations based upon data for Europe and Asia (*12*). The independently determined curves are similar, so we may feel justified in applying the relations to the antarctic continent.

Tsuboi (*13*) has pointed out that only features 160 kilometers or more in

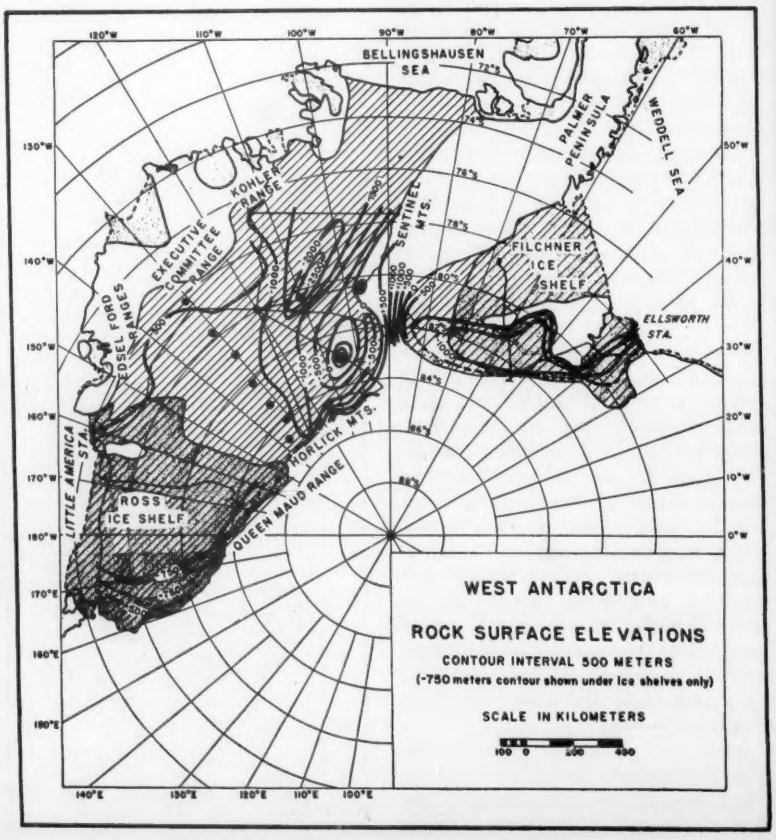


Fig. 3. Rock surface elevations in West Antarctica.

linear extent could normally be expected to achieve isostatic balance. To allow for this and also to minimize the effect of local departures of Bouguer anomalies and elevations from the regional values, both were averaged over intervals of not less than 400 kilometers. Since the relation between surface heights and the elevation of M given by Woollard is based on a normal crust with a near-surface density of 2.67 gm/cm^3, equivalent surface elevations in Antarctica were found by imagining the ice to be replaced by the same mass of crustal material.

Elevations of M obtained from Bouguer anomalies (M_b) and from surface elevations (M_e) have both been computed and are found to be in close agreement, differing by an average of only 0.5 kilometer. Since the values of M_e are based directly on the assumption of isostatic equilibrium whereas those of M_b depend upon the observed gravity values, the agreement between M_b and M_e provides further evidence that West Antarctica is in general isostatic balance.

A contour map based on the values of M_b is shown in Fig. 4. A deepening of M is seen toward all the mountain chains with the exception of the Kohler Range, for which sufficient data are not available. The tentative value of -36 kilometers for the eastern edge of the Victoria Land plateau, based on preliminary gravity figures, corresponds well with the value of -35 kilometers given by Evison, Ingham, and Orr (*14*), based on earthquake surface-wave data. The deep channel is marked by a consistently thin crust, and the M elevation under the channel in Marie Byrd Land is only slightly deeper than it is under the Ross Ice Shelf. The trend northeast from Byrd station of a thin crust supports the inference drawn from the subglacial topography that the channel extends to the Bellingshausen Sea.

The error to be expected in these determinations of crustal thickness should be examined. Since Woollard's curve has a slope of about 15 milligals per kilometer of crustal thickness, the estimated error in the gravity anomalies of 10 milligals corresponds to 0.7 kilometer in M elevation. From Woollard's work it is estimated that the error would be about $\pm$ 3 kilometers in M elevation by either method. This gives an error of about $\pm$ 4 kilometers in the determination of the absolute elevation of M. We may expect that the relative values of M_b and M_e will be more accurate than this, and that the shape of the contours on M in Fig. 4 is generally correct, although subject to a possible shift of a few kilometers up or down.

Summary

The following are the major conclusions reached concerning the structure of West Antarctica.

1) A major channel below sea level between the Ross Sea and the Bellingshausen Sea exists beneath the ice of West Antarctica. This connection is deep enough to have existed before the land surface was depressed by the weight of the overlying icecap. Between Byrd station and the Sentinel Mountains there is a deep basin within the channel in which a maximum depth greater than 2500 meters below sea level is found.

2) The combination of magnetic, geologic, and seismic evidence leads to the conclusion that the channel represents a fundamental division between geologic provinces, separating the volcanic mountains on the north from the folded, metamorphic Sentinel Mountains to the east and the sedimentary, block-faulted Horlick Mountains to the south.

3) The Filchner Ice Shelf is much greater in area and extends much farther to the southwest than had previously been realized. This discovery, together with that of the channel in Marie Byrd Land, has shown that the rock surface of the major part of West Antarctica is below sea level.

4) The Palmer Peninsula structures extend at least as far south as the 83rd parallel and may actually intersect the antarctic horst in the vicinity of 84°S, 80° to 90°W. There is no broad connection below sea level between the Ross and Weddell seas.

5) A deep trough extends inland for several hundred kilometers beneath the eastern area of the Filchner Ice Shelf. A trough is also found under the western and southern boundaries of the Ross Ice Shelf. These troughs may be connected by a narrow topographic low, expressing the break between the folded mountains of the Palmer Peninsula extension and the antarctic horst.

6) Free-air gravity anomalies show

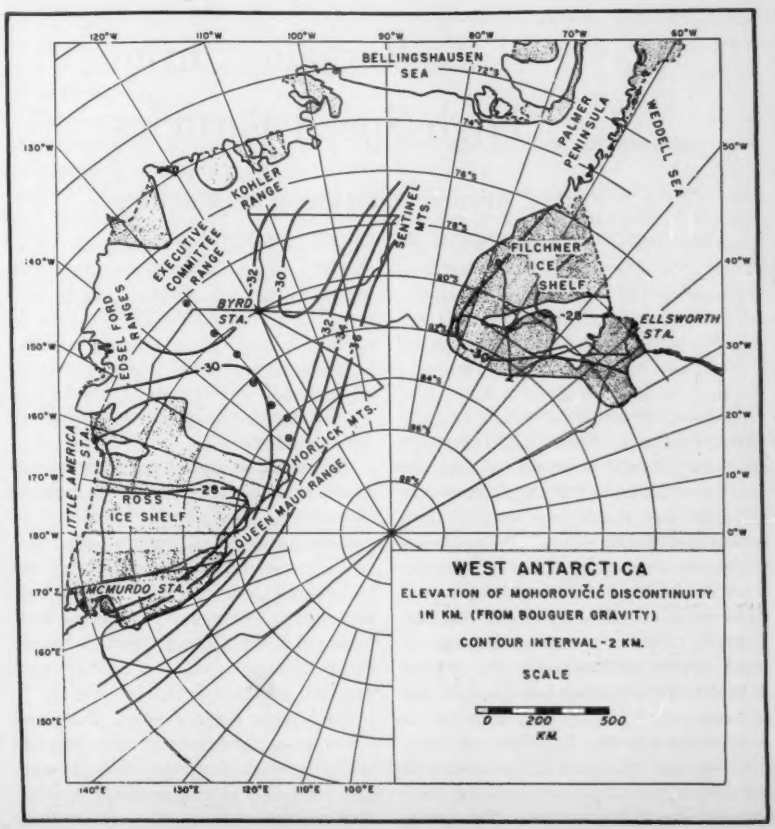


Fig. 4. Elevations of the Mohorovičić discontinuity (in kilometers).

West Antarctica to be in approximate isostatic equilibrium.

7) The crust of West Antarctica is continental in character, but the Mohorovičić discontinuity has the relatively high elevation (exclusive of the mountainous areas) of about 30 kilometers below sea level.

8) The Mohorovičić discontinuity deepens at least to — 36 kilometers, forming a continuous trough beneath the Sentinel, Horlick, and Queen Maud mountains and indicating their general topographic continuity with the Palmer Peninsula.

9) The thinnest crustal sections are found beneath the Ross and Filchner ice shelves, but the elevation of the Mohorovičić discontinuity in these areas is not greatly different from that beneath the large channel in Marie Byrd Land.

10) From the configuration of the ice and rock surfaces it is concluded that the ice sheet in West Antarctica originated as two separate icecaps in the two mountainous areas, one in the vicinity of the Executive Committee Range, the other between the Horlick and Sentinel mountains. As the caps expanded they converged over the open water between and were probably initially joined by a floating ice shelf which then grew thick enough to fill the trough completely and produce the present single-grounded ice sheet.

References

1. E. C. Thiel, N. A. Ostenso, H. F. Bennett, E. S. Robinson, J. C. Behrendt, "IGY Antarctic Oversnow Traverse Program, 1957–1958," in *IGY Glaciological Rept. Ser. No. 1* (American Geographical Society, 1958); E. C. Thiel, C. R. Bentley, N. A. Ostenso, J. C. Behrendt, "Oversnow Traverse Programs, Byrd and Ellsworth Stations, Antarctica, 1957-1958: Seismology, Gravity and Magnetism," in *IGY Glaciological Rept. Ser. No. 2* (American Geographical Society, 1959).
2. C. R. Bentley, L. D. McGinnis, E. S. Robinson, "A study of seismic velocities and related physical properties of the Antarctic ice cap," paper presented at the Antarctic Symposium of Buenos Aires (Nov. 1959).
3. N. A. Ostenso and C. R. Bentley, "The Problem of Elevation Control in Antarctica," in *IGY Glaciological Rept. Ser. No. 2* (American Geographical Society, 1959), sec. iv, pp. 1-26.
4. Personal communication.
5. "IGY Bulletin No. 26," *Trans. Am. Geophys. Union* **40**, 296 (1959).
6. W. E. Long, "Geology of the Central Range, Horlick Mountains, Antarctica," paper presented at the Antarctic Symposium of Buenos Aires (Nov. 1959).
7. W. E. Davis, "Antarctic Stratigraphy and Structure," *Am. Geophys. Union Monograph No. 1* (1956), pp. 44-51.
8. H. A. Neuberg, E. C. Thiel, P. T. Walker, J. C. Behrendt, N. B. Aughenbaugh, "The Filchner Ice Shelf," *Ann. Assoc. Am. Geographers* **49**, 110 (1959).
9. G. Taylor, *Antarctic Research and Adventure* (Appleton, New York, 1930).
10. W. E. Long, personal communication.
11. G. P. Woollard, "Crustal structure from gravity and seismic measurements," *J. Geophys. Research* **64**, 1521 (1959).
12. J. T. Wilson, "Geophysical Institutes of the U.S.S.R. and of the People's Republic of China," *Trans. Am. Geophys. Union* **40**, 3 (1959).
13. C. Tsuboi, "Thickness of the isostatic earth's crust in various parts of the United States," *Geophysical Notes* (Geophysical Institute, Tokyo Univ., 1950), vol. 3, pp. 1-37.
14. F. F. Evison, C. E. Ingham, R. H. Orr, "Thickness of the earth's crust in Antarctica," *Nature* **183**, (1959).

Radiation from High-Speed Particles

Visible radiation that is shown to differ from luminescence phenomena has important applications.

P. A. Cherenkov

The experimental investigation and demonstration of the notable properties of radiation which appears during the motion of fast, electrically charged particles through a substance extends back some twenty-five years. As early as 1934, two reports were published—one by S. I. Vavilov and the other by myself (*1*)—in which it was shown that the gamma rays from radium produce a weak visible radiation of the solvent in addition to the luminescence of the solution.

In these reports, the universal character of this radiation and its unusual properties were described, and the conviction was expressed that the newly discovered radiation could not be a luminescence phenomenon because of its properties.

It was established by further experiments that this radiation is not released directly by the gamma rays, but by rapidly moving Compton electrons, which arise under the action of the gamma rays on the basis of the Compton effect. Attempts to produce a radiation with the same properties by the action of x-rays ($h\nu_{max} = 30$ kev) gave negative results.

One might have thought that such radiation of the solvent would be of no special interest, since radiation phenomena, produced in various ways in solids and in liquids, represent a rather widespread effect. Aside from the generally well-known "classical" luminescence phenomena, one could, for example, mention the weak radiation of practically very "pure" liquids which arises under the action of ultraviolet radiation (*2*). Many liquids emit radiation upon the incidence of x-rays (*3*). Radiation has even been noted in liquids under the action of ultrasonic waves (*4*). Numerous cases of radiation from fluids and solids under the action of radioactive radiations have been well known from the time of Pierre and Marie Curie (*5*).

As a rule, such radiation phenomena are nothing else than ordinary luminescence and are emitted in the case of the so-called "pure" liquid as a result of the presence of a minute amount of luminescence-producing impurities. Therefore, one was inclined to believe that this radiation produced by the gamma rays was one of the many luminescence phenomena. This was presumed by Pierre and Marie Curie, who were undoubtedly among the first to have observed such radiation—of course, under conditions in which this radiation was rather strongly masked by ordinary luminescence.

Dr. Cherenkov is a member of the staff of the Institute of Physics, Academy of Sciences of the U.S.S.R., Moscow.

This article is a translation of the lecture he gave in Stockholm, Sweden, on 10 Dec. 1958, when he was awarded the Nobel prize in physics for 1958, a prize which he shared with I. Y. Tamm and I. M. Frank. It is published here with the permission of the Nobel Foundation. We are indebted to R. T. Beyer for translating the article from the German.

Other observers later reached the same conclusion. Among these was Mallet (*6*), who not only observed this radiation but even photographed its spectrum.

Phenomenon of a New Type

However, a thoroughgoing, quantitative investigation of this radiation process revealed a series of remarkable properties which provided incontestable proof that one was dealing in this case not with trivial luminescence but with a phenomenon of a wholly new type, which was of extraordinary interest not only because of its fundamental meaning but also because of the manifold possibilities for practical application.

Of course, it would be an error to think that so characteristic a phenomenon might not have been discovered earlier by an accidental "error."

The unusual nature of this newly discovered phenomenon could be investigated only through quantitative determination of the most important radiation characteristics and the establishment of their dependence on particular experimental conditions.

Nowadays, since the researcher has at his disposal very intense sources of fast-moving, electrically charged particles, and very sensitive measuring apparatus, such measurements do not present any particular difficulties. However, the means which were available to the physicist a few decades ago were not so satisfactory. Then he had available as sources of electrically charged particles only naturally radioactive preparations, whose intensity was rather slight. For this reason, the intensity of the radiation produced by them in liquids (*7*) was so weak that the radiation could be detected by the observer only after he had spent some time in absolute darkness. It stands to reason that, under such conditions, the ordinary methods of photometry for the quantitative determinations do not enter into the picture (*8*). A new and much more sensitive method was necessary for carrying out such determinations. At the Institute of Physics, Academy of Sciences of the U.S.S.R., where this phenomenon was discovered, the method developed shortly before by E. M. Brumberg and S. I. Vavilov (*9*) was applied. This was the method of visual photometry based on the sensitivity limit of the eye, or, as it is otherwise known, the method of extinction. This method made use of the human eye (*10*) in place of the light-measuring device. Since the sensitivity of the dark-adapted eye is at least several tens of thousands of times greater than the sensitivity of the eye in daylight, this method is distinguished by a rather high sensitivity in comparison with other methods. Notwithstanding the subjectivity of the method, and the admittedly large error which was associated with the measurements, it was at the time a very useful method, which permitted a quantitative determination of extremely small light intensities.

It is of fundamental importance to note that this method first permitted a transition to quantitative determinations, the proving of the unusual properties of the observed radiation, and the demonstration of their particular origin.

Luminescence Hypothesis Ruled Out

It has already been pointed out that the first and most plausible hypothesis in explanation of this radiation referred to luminescence phenomena. The correctness of this assumption was now to be confirmed only by showing experimentally, for this radiation, the presence of only the characteristic properties of luminescence.

But there now exist a great number of luminescence phenomena, which are distinguished among themselves by the method of excitation, the duration of the decay, the character of the spectrum, the properties of the luminescent substances, and other marks. In the case of interest to us, it is not a question of simply determining the presence or absence of signs of luminescence but of determining the important characteristics which clearly identify the luminescence phenomenon for what it is.

As was pointed out by S. I. Vavilov, one such characteristic of luminescence is the total duration of the excited state ($\tau > 10^{-10}$ sec). This property of luminescence has its influence on the decay process. For example, one can weaken the brightness considerably or, in other words, "quench" the luminescence either by heating the luminescent solution or by adding material which is capable of quenching the luminescense. In both cases, a weakening of the luminescence results as a consequence of an energy transfer from the excited particles to the unexcited, and of the subsequent transformation of the energy into heat.

Likewise, the polarization of the luminescence can be changed if the mobility of the particles is changed—for example, by heating.

But the corresponding experiments with this radiation showed that the brightness of radiation of the liquid cannot be affected either by heating or by dissolving in the solution such active fluorescence-quenchers as potassium iodide, silver nitrate, and so on. It has also been pointed out that the perceptible polarization appearing in this radiation is likewise unchangeable. It is of fundamental importance that in experiments intended for study of the quenching of fluorescence of undoubtedly fluorescent solutions (such as a water solution of esculin), carried out in parallel and under identical conditions, a visible quenching effect was in all cases exhibited.

These results indicated a virtually inertia-free character of the decay process and excluded the hypothesis of luminescence. This conclusion also found support in the unusual character of the polarization of this radiation. The direction of the electric oscillation vector was not perpendicular to the exciting beam of radiation, as is the case in polarized fluorescence, but was rather parallel to it.

Spatial Asymmetry of Radiation

The sum of the results collected during this first stage led to the conclusion that the radiation produced in the liquid under the action of gamma rays was no trivial phenomenon. However, these facts were not sufficient for construction of an objection-free theory of the phenomenon on such a basis. This problem was solved somewhat later, after a new, especially noteworthy, property of this radiation—its pronounced asymmetry, its directional character—was discovered, in 1936 (*9*, *10*).

It turned out that the radiation showed an extremely pronounced spatial asymmetry. This radiation is sent only forward, in a direction which forms a definite angle with the exciting beam of gamma rays.

The discovery of this fundamental property of the radiation proved to be a decisive step toward explanation of the true physical nature of this phenomenon and toward formulation of a theory. The creation of this theory was the contribution of I. M. Frank and I. E. Tamm (*11*).

True Nature of the Emission

This theory starts out from the idea that the described radiation is produced by electrons which move uniformly in the substance with a velocity which exceeds the phase velocity of light in this medium.

It is of interest that as early as 1901, Lord Kelvin (*12*) maintained that the emission might be produced by particles which travel with a superlight velocity.

Somewhat later, in the years 1904 and 1905, shortly before the appearance of the theory of relativity, Sommerfeld (*13*) considered theoretically the hypothetical case of the motion in a vacuum of an electron with a superlight velocity.

However, the appearance of relativity theory, which maintained that material bodies are not capable of achieving the velocity of light in their motion, much less a superlight velocity, allowed the conclusions of Sommerfeld to fall under a shadow, as being of little significance.

It is apparently due in some measure to this circumstance that the problem of the motion of electrically charged particles in a substance has generally been little considered, since this was thought not to be reconcilable with the theory of relativity.

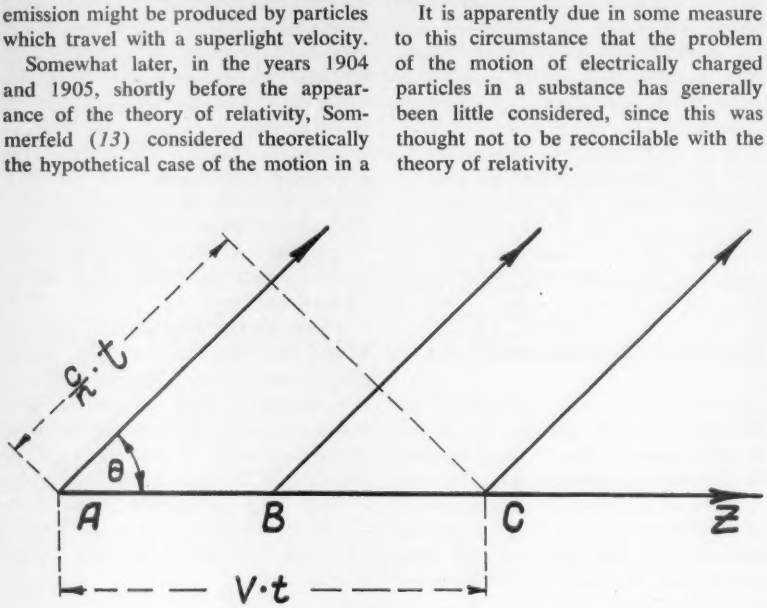


Fig. 1. Radiation mechanism.

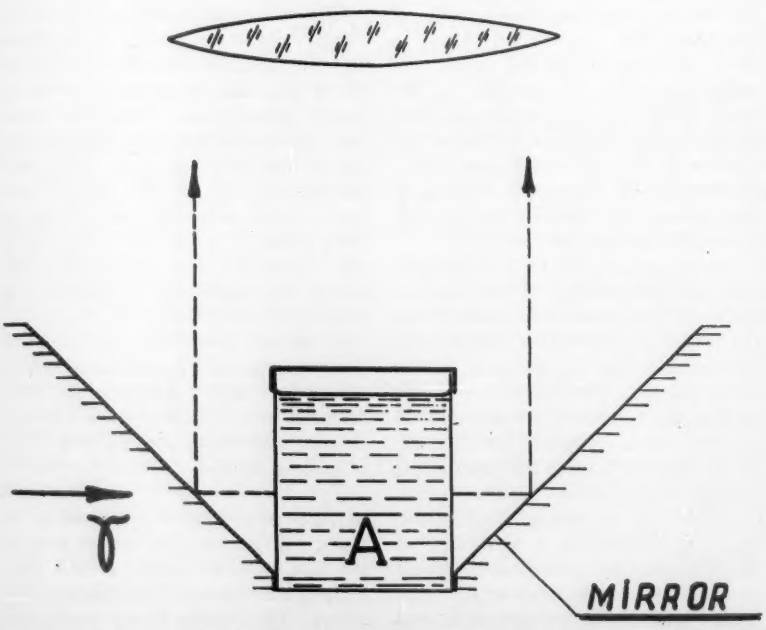


Fig. 2. Arrangement of apparatus for determination of the angular distribution of the intensity.

In the case of the motion of the charge in a substance, there are velocities which exceed the velocity of light, which are possible without being in conflict in any way with relativity theory.

This fact is explained by the circumstance that the propagation velocity of light waves in a substance differs from the velocity of light in a vacuum by a factor n, where n is the index of refraction of the medium in which the motion takes place.

Since $n > 1$ for visible light, and since the propagation velocity of the light waves in the medium is equal to c/n, this is consequently smaller than c, the velocity of light in a vacuum.

On the other hand, it has long been known that the velocity of beta particles, which are emitted from radioactive substances, can come very close to the velocity of light c. These particles, in their motion in a given substance, can possess a velocity which is greater than the light velocity c/n in this substance and yet remains smaller than c, in complete agreement with the requirements of relativity theory. Therefore, the motion of the particles with superlight velocity is not only possible in principle but can be achieved experimentally.

If we assume that the velocity of an electron moving in this medium exceeds the velocity of light, we can determine the preliminary conditions for the appearance of such radiation on the basis of simple qualitative investigations and obtain some very important properties of this radiation. Let us assume that an electron executes a uniform motion in the medium in the direction of the z-axis with a velocity $v > c/n$. At each point reached by the electron, an electromagnetic excitation is produced which is propagated in the form of a retarded wave from that point.

If we consider the components of a particular frequency ω of the waves, which leave the various points at an angle θ to the path of the electron (see Fig. 1), then we can easily be convinced that the waves will be canceled by interference in all directions other than in that for which

$$vt \cos \theta = ct/n, \text{ or } \cos \theta = 1/\beta n \quad (1)$$

On the other hand, in the direction which satisfies condition 1, the waves reach the observer with an optical path difference equal to zero, and accordingly the radiation takes place only in this direction.

This radiation has its analog in acoustics in the form of the so-called ballistic wave which is produced by a projectile or airplane which moves with supersonic velocity (Mach waves). A surface analog is the well-known bow wave.

It follows from Eq. 1, which forms one of the most reliable results of the theory of Tamm and Frank, that the appearance of the radiation is possible only under the condition $\beta n > 1$—that is, when the velocity of the particle v exceeds the velocity of light c/n. As a consequence, the equation $\beta n = 1$ expresses the threshold energy value of the radiation. The value E_0 of this threshold is determined by the index of refraction. Since the condition for the determination of this limit contains the velocity of the particle rather than the energy directly, it is evident that E_0 also depends on the mass of the particle.

In order to illustrate what has been developed above, values of the threshold energy E_0 are given in Table 1 for electrons, π-mesons, and protons for three different values of n.

Table 1. Values of the threshold energy for electrons, π-mesons, and protons for three different values of n.

Type of particle	Value of threshold energy (mev)		
	$n = 1.3$; $\beta = 0.769$	$n = 1.5$; $\beta = 0.67$	$n = 2.0$; $\beta = 0.50$
Electron	0.29	0.2	0.078
π-Meson	79	47	21.5
Proton	520	320	143

Experimental Confirmation

The theoretical relation among the quantities θ, β, and n, which is given by relation 1, was experimentally proved. The results obtained agreed completely with the deductions of the theory. The experimental arrangements for the determination of this dependence are illustrated in Fig. 2.

The beam of gamma rays is incident on a thin-walled tube, filled with liquid (A in Fig. 2). The radiation arising in this liquid upon its emergence from the canal falls on a conical mirror and is reflected to the objective of a photographic apparatus. The luminescence produces a picture in the form of a closed ring, since it exhibits no asymmetrical properties.

On the other hand, the radiation of the particles with superlight velocity does not form a closed ring in the picture, but rather two spots, the angle between them being equal to 2θ.

Figure 3 (right, middle) shows a sample of such photographs for two pure liquids (water and ethyl cinnamate). For comparison, a photograph of the luminescence of an aqueous solution of esculin is also shown in Fig. 3 (left).

The angular distribution of the radiation intensity (for four liquids) determined by measurements on these photographs are shown in Fig. 4. For each of these liquids, two curves are obtained, which correspond to the excitation of radiation by gamma rays of ThC″ (the upper curves) and by the gamma rays from Ra (the lower curves).

It is a simple matter to determine the angle θ by means of the graph in Fig. 4. The value of this angle increases with increase in the index of refraction n, exactly as the theory requires. For one and the same liquid, results were obtained which yielded larger values of θ in experiments with the gamma rays of ThC″ than in experiments with the gamma rays of Ra. This difference in the measurements for $\theta_{\text{ThC}''}$ and θ_{Ra} permits one to use relation 1 for determination of the "effective" velocity ($\beta_{\text{eff.}}$) of the Compton electrons which excite the radiation. These velocities are 0.869 and 0.847, respectively. This result corresponds exactly to the higher energy of the gamma rays of ThC″.

If the picture is observed not in the plane but in space, then the radiation must spread out along the surface of a cone whose axis is the path of the electrically charged particle, while the generating line of the cone makes the angle θ with this axis.

If the photographic plate is placed perpendicular to the beam of fast-moving particles (Fig. 5), a photograph of the radiation in the form of a ring is obtained (Fig. 6), in addition to the picture of the trace of the beam. Figure 6 was obtained by means of a narrow beam of protons ($E = 660$ Mev) on the accelerator of the Combined Institute for Nuclear Research at Dubna.

Thus far, we have considered only a definite frequency ω. Actually, however, the radiation spectrum is continuous. Since the medium exhibits dispersion properties—that is, since the index of refraction is dependent on the frequency—the light of different wavelengths departs at angles which differ somewhat from one another, even for a constant particle velocity.

The radiation is therefore split up in spectral analysis. The radiation cone then exhibits a definite strength, in which, in the case of a medium with normal dispersion, the red spectrum lies at the inner side of the cone, while the violet lies at the outer side.

Thus, interpretation of the radiation mechanism proposed by Tamm and Frank, even in a qualitative consideration, gave an explanation of the especially characteristic properties of this radiation—such as, for example, the asymmetry, the short decay time, the presence of an energy threshold, and the universal character of the radiation. Moreover, the rigorously quantitative theory yields an expression for the energy W which the electron furnishes in this radiation. This expression has the form

$$W = \frac{e^2 l}{c^2} \int_{\beta n > 1}^{\omega} \left(1 - \frac{1}{\beta^2 n^2}\right) d\omega \quad (2)$$

where l is the path length of the electron. It also follows from this that the energy of the radiation spectrum is proportional to $1/\lambda^3$—that is, that it increases sharply in the direction of short wavelengths.

The radiation ceases in the x-ray region, since in this interval, $n < 1$.

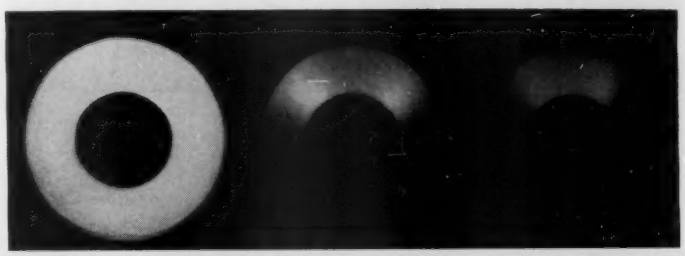


Fig. 3. Photograph of the angular distribution of intensity for (left) ordinary luminescence (solution of esculin in water); (middle) radiation from ethyl cinnamate ($n = 1.5804$); (right) radiation from water ($n = 1.3371$).

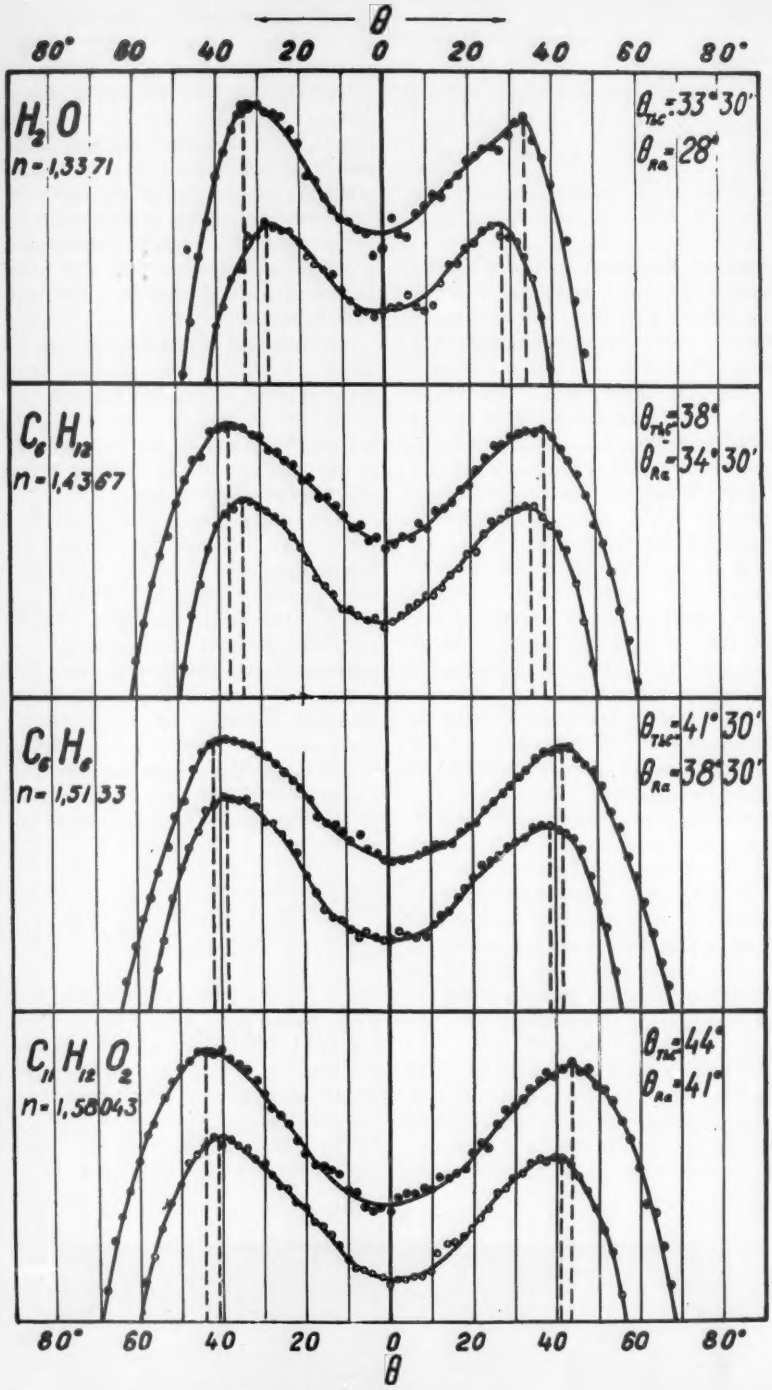


Fig. 4. Angular distribution of intensity for liquids with different n, obtained from photographs like Fig. 3. The curves through the solid circles correspond to the excitation of radiation by Compton electrons from the gamma radiation of ThC″. For these, $\beta_{eff.} = 0.869$ (according to Eq. 1). Curves through the open circles correspond to excitation by Compton electrons resulting from the gamma rays of Ra. In this case, $\beta_{eff.} = 0.847$.

Finally, it was deduced from the theory that the radiation must exhibit polarization; indeed, it must have the same polarization which was determined in the first experiments: the vector of the electric oscillations lies in the plane containing the ray and the direction of motion of the particles.

All this shows that the theory under discussion comprehended all the currently known properties of the new radiation in an exhaustive fashion. The development of this theory concluded a great cycle of investigations which included the discovery, the over-all experimental investigation, and the development of the theoretical foundations of the phenomenon, all of which gave rise to the establishment of a new area of physics, the optics of beams which move with superlight velocities.

As a consequence of the lack of sufficiently sensitive and convenient measuring apparatus, interest in the new radiation was great, to be sure, but was only of an abstract character. Its inherent potentiality for practical application, especially in experimental physics, remained untried.

However, in recent years, as a result of the development and production of photomultipliers, radiation from fast, electrically charged particles took on an important practical meaning, especially in the domain of physics of high-energy particles.

Measurement of Intensity

Although the intensity of the radiation flashes produced by individual particles is vanishingly small, it is, today, measurable. It follows from Eq. 2 that when $\beta \cong 1$, the number of photons in the visible portions of the spectrum which are sent out by an electrically charged particle which moves in a medium with $n \cong 1.5$ amounts to 200 to 300 photons per centimeter. By a correct choice of the shape and position of the radiator (this name is given to the medium in which the radiation-producing charged particles move), a significant portion of this light can reach the cathode of the photomultiplier. As a result of the great amplification, a current pulse appears at the anode of the multiplier which is a million times greater than the initial current. This pulse can be determined by an appropriate electronic circuit, and hence the particle can be detected. Such an ap-

paratus represents a counter in which the radiation emitted by the particle serves directly for its measurement.

This type of counter is strongly reminiscent of the so-called scintillation counter, in which the luminescence which arises in the absorption of the energy of the particle in a scintillator is used for the measurement of an electrically charged particle. This measurement is also carried out with the aid of a photomultiplier. However, in comparison with the scintillation counter, this counter has a number of important advantages. These advantages are as follows. (i) The short duration of the decay permits counters to be developed which exhibit a very high resolution. (ii) The presence of an energy threshold makes counters of this type insensitive to slow particles which are below the threshold energy. This property of the counter is especially valuable in cases in which there is present a significant radiation spread produced by gamma rays. (iii) The asymmetry of the radiation permits a measurement of only those particles which move in the radiator in the direction of the cathode of the photomultiplier. Particles which move in the opposite direction will not be measured by the counter. In other words, the counters of this type are distinguished by the presence of a definite directivity.

This property of the counter was used by Winckler (*14*) for determination of the "albedo" of cosmic rays in the upper layers of the atmosphere.

At present, a great number of counters of the type mentioned, which are distinguished by their original construction, are described in the works of Jelley, Marshall, and others (*15*).

Applications

The methodological value of the radiation of fast-moving particles lies not only in the possibility of their use as particle detectors. The exploitation of the singular properties of this radiation (often in conjunction with other methods) enlarges—in a number of cases, significantly—the possibilities of physical experiment.

Thus, it is known, for example, that determination of one of the most important parameters of a particle—its mass—can be carried out on the basis of measurements of its momentum and its velocity. Usually, experimental difficulties are encountered in the velocity measurements. It is clear, without further comment, that the velocity of a particle can be easily computed from the measured value of θ and the known index of refraction, within the velocity range of the particle over which β (which satisfies the condition $\beta n > 1$) differs sufficiently from unity.

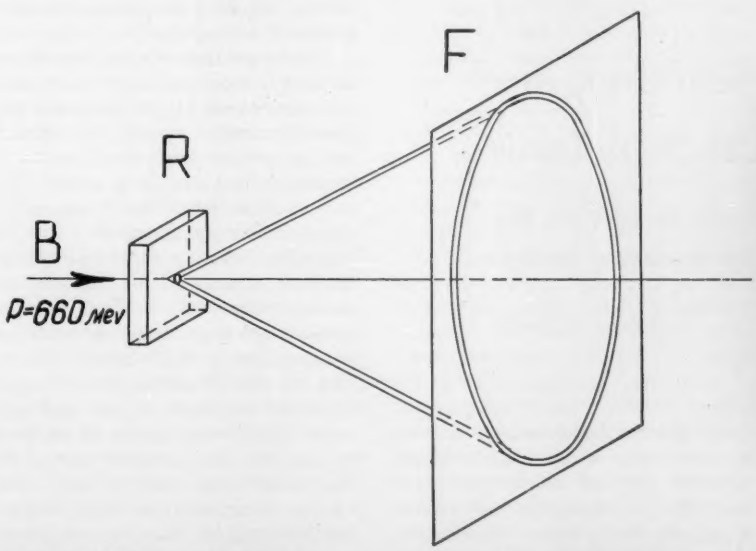
If the type of particle is known, velocity measurements also permit the energy to be measured. Especially good results are yielded by this method in the measurement of the energy of protons from accelerators for energies which lie in the range of several hundred Mev (see Table 1). The accuracy of such energy measurements is within 0.25 percent (*16*).

It has been noted above that the circumstance that the radiation possesses an energy threshold makes the counter insensitive to particles of low energy. The possibility therefore exists of changing the threshold energy E_0 by selecting a radiator with a suitable value of n.

It is clear that two counters which have been previously set up with different values of the threshold energy, E_0' and E_0'', and are connected in appropriate sequence in an anticoincidence circuit will record only those particles whose velocity is in the range from E_0' to E_0''.

Such an arrangement was successfully applied by Segré and his co-workers in their outstanding work which led to the discovery of the antiproton.

Another interesting region of application of the properties of the rays was found in their use in the investigation of broad cosmic-ray showers. In the study of these showers with ordinary counters, only those particles are measured at a certain height which are the distant "descendants" of the primary



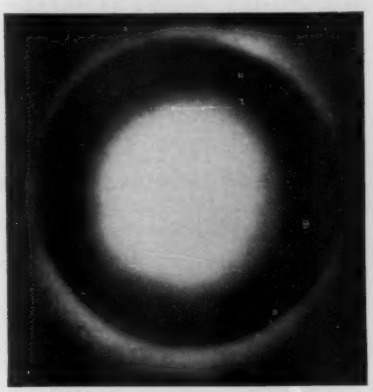


Fig. 5 (left). Experimental arrangement for obtaining photographs of the conical cross section in the plane of the photographic plate. Fig. 6 (right). Photograph of a cross section of the radiation cone which was obtained in an experiment in which the arrangement shown in Fig. 5 was used. The central spot is the trace of the proton beam. [A. P. Srelow]

particle. None of the other particles which appear and disappear during the previous development stages of the shower can be measured by this apparatus. But since the shower particles possess enormous energies, they are capable of producing radiation in the air of the type under discussion, which is propagated in virtually the same direction. This radiation, under favorable conditions, reaches the earth's surface and can be measured by a photomultiplier. This method furnishes a more complete picture of the shower and valuable information about the process of its development.

For cosmology, the problem of the distribution of nuclei in the cosmic radiation (outside the earth's atmosphere) which are heavier than the hydrogen nucleus is of great importance. Appropriate experiments are being carried out on the sputniks at the present time. In these experiments, reliance is placed on the circumstance that the intensity of the radiation of particles which move with superlight velocity is proportional to the square of the particle's charge. Therefore, the pulses coming from particles of different charges and recorded by the counter may be distinguished by their amplitudes. Analysis of the amplitude distribution will permit one to make judgments on the distribution of heavy particles in the cosmic radiation, corresponding to their ordinal number.

The last thing on which I would like to speak is the application of the radiation from fast-moving particles to measurement of the energy itself when this energy is rather large. In this case measurement of the energy of the particles by means of their deflection in a magnetic field is no longer possible. However, one can try to determine it by measuring the total energy which the particle gives to the radiation of the type under consideration. For this purpose, very transparent, thick radiators must be used, which give off radiation of a sufficient intensity and which permit a complete development of the shower.

Water is a suitable radiator in this case. Equipment has been constructed in the Institute of Physics, Academy of Sciences of the U.S.S.R., which should serve for the measurement of the energy of cosmic particles by means of this method.

The examples we have given show the great importance to experimental physics of the radiation produced by particles which travel with superlight velocity (*17*).

However, not all the possible applications have been discussed. It is undoubtedly true that the region of application of this radiation will continue to expand rapidly in the years to come.

References and Notes

1. S. I. Vavilov, *Doklady Akad. Nauk S.S.S.R.* **2**, 457 (1934); P. A. Cherenkov, *ibid.* **2**, 451 (1934).
2. S. J. Wawilow [Vavilov] and L. A. Tummermann, *Z. Physik* **54**, 270 (1929).
3. H. S. Newcomer, *J. Am. Chem. Soc.* **42**, 1997 (1920).
4. H. Frenzel and H. Schultes, *Z. physik. Chem.* **27**, 421 (1934).
5. E. Curie, *Madame Curie* (London, 1941).
6. L. Mallet, *Compt. rend.* **183**, 274 (1926); *ibid.* **187**, 222 (1928); *ibid.* **188**, 445 (1929).
7. The investigation of the given phenomenon was carried out principally in liquids, since the liquids were more easily purified of luminescence-producing impurities. It is also easier to change such parameters as viscosity, index of refraction, density, and so on, in liquids. Moreover, attempts to quench the luminescence in this case were considerably simplified.
8. It must be remembered that the photomultiplier had not been developed at that time.
9. E. M. Brumberg and S. I. Vavilov, *Izvest. Akad. Nauk OMEN Ser.* 7 (1933), p. 919.
10. The method of extinction, which is only of historical interest today, was based on the following properties of the human eye: (i) the presence of an optical sensitivity limit and (ii) stability of the magnitude of the threshold energy for a given observer (under constant conditions).
11. I. E. Tamm and I. M. Frank, *Doklady Akad. Nauk S.S.S.R.* **14**, (1937).
12. Lord Kelvin, *Phil. Mag.* **2**, 1 (1901).
13. A. Sommerfeld, *Nachr. Akad. Wiss. Göttingen* **99**, 363 (1904); *ibid.* **100**, 201 (1905).
14. J. Winckler, *Phys. Rev.* **85**, 1054 (1952).
15. J. V. Jelley, *Cerenkov Radiation and Its Applications* (Pergamon, New York, 1958).
16. R. L. Mather, *Phys. Rev.* **84**, 181 (1951).
17. For further discussions, see P. A. Cherenkov, *Doklady Akad. Nauk S.S.S.R.* **12**, 413 (1936); ———, *ibid.* **14**, 99 (1937).

Machine Searching for Chemical Structures

The Wiswesser notation provides an effective key to literature searches for functional groups.

Elbert G. Smith

The use of punched-card machines for organizing and retrieving chemical data has been described by a number of workers in recent years (*1*). These techniques make it possible to find and arrange information about large numbers of items very rapidly and efficiently, provided that the information about each item is not too extensive. Since this is precisely the situation we face in dealing with data about chemical compounds (large numbers of compounds but rather limited data, such as structure or properties, about each one), it would seem feasible to organize and search this kind of information with punched-card techniques.

A principal difficulty has been that of devising a means of identifying chemical compounds in an intelligible way which is concise enough for efficient use on punched cards. Ordinary names are usually too long to be efficient and do not allow use of the machine's potential ability to search for units of molecular structure in the identifying name. A solution of this difficulty lies in the concept of a new chemical notation in which units of chemical structure are designated by single letters and numbers, so that structural formulas may be spelled out much as one spells out words. Such notations can be designed so that they are intelligible both to the chemist and to the machine, and in such a happy combination we might look for practical and reasonable means of accomplishing the mechanical organization and retrieval of much chemical information.

The author, now associate professor of chemistry at Mills College, Oakland, Calif., did the work described in this article at the University of Hawaii, Honolulu.

Wiswesser Notation

The Wiswesser notation (*2*) meets these requirements very well. It is intelligible at sight to any chemist who will learn about a dozen new symbols to supplement the old familiar ones and some of the more essential rules for using them. It is also intelligible to punched-card machines because it does not use any symbols that cannot be expressed on existing machines. It is so concise that at least 98 percent of the organic compounds of known structure in such a compilation as *Heilbron* can be expressed in notations which require less than half of the information space on a single IBM card. The rest of the card then can carry other information about the compound, and the resulting single card for a single compound greatly simplifies the machine problems in finding and reproducing desired information. No other notation yet proposed can meet so well these essential requirements of intelligibility and conciseness.

The Wiswesser notation gives unique patterns of letters and numbers for each different structural formula, so there is only one place to look in any alphabetically arranged list of notations for any given compound. The problem of locating data about a specific compound is thus solved directly by the notation itself. Searching for groups of compounds with the same functional groups is more difficult, however, since symbols for a particular functional group may occur at any point in the line-formula notation and so may occupy any column or group of columns in the part of an IBM card punched with the notation. Since punched-card machines do not scan the card lengthwise along the notation but at right angles to it along one or more vertical card columns (each representing a single letter or number), all the cards would have to be sorted in all the columns of the notation field (and letters require double sorting) to find all the cards carrying a particular notation symbol. This would be such a tedious and time-consuming operation that machine searching of cards for groups of compounds with similar functional groups would be an impossible undertaking. To make matters worse, only very expensive types of machines can scan more than one card column (and so find more than one notation symbol) at a time. If the desirable properties of the Wiswesser notation are to be used to advantage, they therefore must be supplemented by some additional searching code adapted to finding the cards carrying particular symbols, preferably by use of the simpler and less expensive, single-column sorting machines.

Table 1. Two column code for showing elementary atom count.

Punch position	Column 1 No. of carbon atoms	Column 2 No. of other-element atoms
12	10	1 Oxygen
11	20	2 Oxygen
0	40	4 Oxygen
1	1	8 Oxygen
2	2	1 Nitrogen
3	3	2 Nitrogen
4	4	4 Nitrogen
5	5	1 Halogen
6	6	2 Halogen
7	7	4 Halogen
8	8	1 Other
9	9	2 Other

Searching Code Proposals

Wiswesser (*4*) has suggested a code of this kind in which each letter symbol from the notation for a particular compound is indicated by a single punch in one of 26 fixed positions in a three-column section of the punched card. Thus, cards with notations containing the symbol V (the carbonyl connective, –CO•–) would be punched in position 5 of column 3, and cards containing the symbol M (the –NH– group) would be punched in position 4 of column 2. By a single sort of the card file for position 5 in column 3, all cards for compounds containing carbonyl connective groups could be removed. If one desired to find compounds with the structure –CO•NH– (-VM- in Wiswesser notation), the cards found on the first sort (for V) would then be searched for M symbols by sorting them on position 4 in column 2.

Unfortunately, in practice, entirely too many unwanted cards are produced by such a searching code, particularly if one is searching for single-symbol functional groups. A search for ketones (V) would also produce many cards for compounds carrying V symbols in other functional groups which are not ketones at all—amides, ureides, anhydrides, acid halides, and so on. In other words, the simple letter code is not sufficiently selective to do a satisfactory job. At the same time, some of the positions in this searching field proposed by Wiswesser are either very seldom used or are meaningless in terms of organic molecular structures (*5*).

For these reasons a modification of this searching code was devised on the basis of exhaustive frequency counts of symbols and symbol combinations in the Wiswesser notations for some 10,000 common organic compounds. This code has been tested and revised a number of times during the past six years on a continually growing punched-card catalog of organic notations which now contains data on 50,000 compounds. A number of machine searches were carried out when the catalog contained 24,700 compounds, and another series was run when the catalog had been expanded to 50,000 compounds. The resulting searching code, presented in Tables 1 and 2, is thus a strictly practical effort to facilitate the finding of compounds with particular structures. Each definition in Table 2 is the result of some years of experience with the problems involved.

The searching code so evolved was punched into the first five columns of the IBM cards used, and so the columns in Tables 1 and 2 are numbered accordingly. Table 1 shows the code used to record the carbon, oxygen, nitrogen, halogen, and "other atom" counts. With multiple punching in the top three positions in column 1, up to 79 carbon atoms can be indicated. Multiple punching within each group in column 2 will indicate up to 15 oxygen atoms, 7 nitrogen atoms, 7 halogen atoms, and 3 other atoms. In each case the maximum number is used to indicate that number or more of the atom in question. No difficulties have been found in practice for the rather minor use made of this part of the searching code.

Structure-Searching Code

The real heart of the searching method is the three-column structure-searching code shown in Table 2. Each column has 12 punching positions, and the categories are arranged according to elementary type. One of the 36 positions is unassigned so that it may be used for special purposes where needed. As shown in Table 2, the 35 categories fall into two classes: (i) symbols or groups of symbols which commonly occur alone in organic notations of a given functional type (acids, ketones, ethers, esters, and so on) and (ii) symbols or groups of symbols which can be combined with each other to express more complex functional groups (sulfonic acids, ox-

imes, amides, anhydrides, and so on).

For example, the symbol Q, denoting the –OH group, occurs alone in phenols (column 4, punch position 4) and in alcohols and enols (column 4, punch position 5). The Q symbol also occurs in combination with other symbols in oximes, sulfonic acids, some inorganic acids, the carboxyl group, and so on. Unless separate searching-code positions are assigned to Q symbols in phenols and alcohols, these cards cannot be separated effectively from each other or from cards for oximes, sulfonic acids, and so on. By assigning a separate punch to "Q attached to non-carbon atoms" (column 4, punch position 6), this difficulty is solved and at the same time the number of Q cards that must be dealt with in a given search is greatly reduced.

Searching Procedures

In the first class of categories mentioned above it is clear that highly efficient searches for compounds with more than one functional group can be carried out. For example, if one wants the cards for unsaturated acids containing bromine atoms, the card file would be run through the sorting machine with the sorting switches set to select only the cards punched in column 3, punch position 0 for E (bromine). The cards so selected would then be sorted on column 5, punch position 12 for U (unsaturation). The cards selected on this sort would then be sorted on column 4, punch position 12 for QV (acids). This would produce all the cards in the entire file which carry notations with the three structural units desired. Obviously, in this type of search, no unwanted cards could be produced. In other words, the searching efficiency would be 100 percent with the machine alone.

In the second class of categories the searching efficiency is usually less, but the searching procedures are more interesting since they require a bit more ingenuity. For example, in searching the "Q attached to non-carbon" category for various functional groups containing the Q symbol, separations are made by sorting for the other symbols combining with Q in the functional group desired. In searching for sulfonic acids (WSQ- or -SWQ in Wiswesser notation), the Q cards are sorted for WS symbols (column 5, punch position 2). Only those cards so selected can carry sulfonic acid notations. In searching for oximes (QNU- or -UNQ in Wiswesser notation), the cards carrying Q symbols are sorted for "N attached to one or two non-keto carbons" (column 3, punch position 7), and the cards so selected are sorted finally for "U attached to non-carbon" (column 5, punch position 11). Only the cards so selected can carry notations of oximes.

Unwanted Cards

In three-step searches of this kind there is an astonishingly small number of unwanted cards—those carrying random coincidences of the desired symbols in undesired combinations. In searching for oximes among 24,700 compounds of all types, 629 cards were found by the three-step sorting procedure described above. Inspection of the notations showed that 612 were oximes. The unwanted cards often can be removed mechanically by sorting for unwanted symbols that commonly occur attached to one of the wanted symbols. In this case the 629 cards were sorted for WS symbols (column 5, punch position 2), since these commonly occur with Q symbols in sulfonic acids. This sort produced 13 cards; one of these was an oxime but the other 12 were not. Thus the "contamination" was reduced to five unwanted cards, among cards for the 612 oximes actually present, by a purely mechanical operation.

In general, the more symbols one can specify for a given search, the fewer unwanted cards one obtains. In a search for semicarbazones, $H_2N{\cdot}CO{\cdot}NH{\cdot}N$: (ZVMNU- or -UNMVZ in Wiswesser notation), where four searching-code categories are specified—Z, MV, N, and U—350 cards were found in the four-step sorting of the 24,700-compound file. All but one of the 350 were semicarbazones. This is not a selected example; this is exactly the probable contamination one might predict statisically from the frequency counts of the four categories shown in Table 2. As verification, a similar search for semicarbazones was made when the catalog had reached 50,000 compounds. The four-step sorting produced 1097 cards, and all but two were semicarbazones.

Searching Time

The total time required for a search depends partly on the speed of the sorting machine, partly on the sorting sequence chosen, and partly on the amount of visual inspection of the notations that is needed. Searches obviously should start on the symbol with the lowest frequency in Table 2, so that the greatest possible number of unwanted cards will be removed on the first pass through the sorter. The most commonly used IBM sorter, with a speed of 650 cards per minute, required from 35 to 40 minutes to sort the deck of 24,700 cards. In a later phase of this work a sorter with a 1000-card-per-minute speed became available, and this required just under an hour to sort the 50,000 card deck.

Category Decks

Since this first step in a search is obviously the most time-consuming, a means of eliminating it was sought. The total number of searching-code punches, calculated from the frequency counts in Table 2, is only about 2.9 times the total number of compounds. If one omits the least discriminating (U-non-carbon and Y) categories, this factor is reduced to about 2.5 punches per compound. The same factor of 2.5 was found at both the 24,700- and the 50,000-compound levels. This relatively small factor suggested a simple way to avoid repeated sorting of the entire catalog: sort out each category in turn, duplicate the cards, and keep each of these new category decks in a separate card file. In this way the entire deck never need be sorted again, and each category deck is available at once for any searches in which it is needed. As new compounds are added to the file, the additional cards for each category deck file are easily prepared and filed in their appropriate decks. This duplication by categories not only saves much time in searching but avoids wear and tear on the master cards. These can be kept in alphabetical order by notation for rapid location of individual compounds, for assigning card serial numbers to new entries, and for other purposes. Card duplication of this sort is purely mechanical with an appropriate IBM machine and is foolproof and inexpensive. The relatively low card multiplication factor of 2.5 makes this a feasible and economical procedure.

Some Functional Group Searches

Many searches can be speeded further by keeping the cards in alphabetical order within each category deck. In the search for oximes among 24,700 com-

pounds, the Q-non-carbon category deck of 1451 cards was used. About 300 of these carried notations beginning with the desired combination, QNU-. Removal of these from the category deck left less than 1200 to be sorted for the N and U category symbols on the sorting machine. The first sort on the machine required about 2 minutes, and the entire search was completed in less than 5 minutes.

In the semicarbazone search on 24,700 compounds described above, the MV-non-carbon category deck of 827 cards was used. The cards with notations starting with ZVMNU- were quickly removed by visual inspection of the alphabetized deck, and the remaining cards were sorted for the Z, N, and U punches. The cards so selected were alphabetized by sorting on a serial number punched in the cards for this purpose. These cards were added to those in the ZVMNU- group, which were already in alphabetical order, and the entire group was run through an IBM tabulating machine which listed all of the printable data from the cards. The entire operation, starting with the alphabetized MV category deck and finishing with an alphabetized, printed list of semicarbazones, required only 15 minutes. The cards for semicarbazones were then arranged mechanically by melting point of the compound, in ascending order, and listed on the tabulating machine in this order. This required another 15 minutes. With a more modern tabulator than was available for this work, and with continuous-feed printing forms, the listing time could have been materially reduced.

Control of Unwanted Cards

Searches involving only two symbol specifications produce a larger number of unwanted cards, but alphabetized category decks permit visual removal of wanted and unwanted portions, and this accelerates the mechanical search. For example, in searching 24,700 compounds for unsubstituted amides, $-CO{\cdot}NH_2$ (-VZ or ZV- in Wiswesser notation), the V-non-carbon category deck of 1536 cards was used, since this was smaller than the Z deck. Removal of the desired cards with notations beginning with ZV- left some 1200 cards to be searched mechanically for Z in column 3, punch position 9. This sort produced only 100 cards carrying both Z and V symbols in which visual inspection for -VZ combinations was necessary. Visual inspection of the ZV- group allowed quick removal of some unwanted ZVM-, ZVN-, and ZVS- combinations. The search was completed in 7 or 8 minutes.

Selection of symbols nearer the beginning of the alphabet is a bit more difficult because the basic orienting rule of the Wiswesser notation tends to place these in terminating rather than in initiating (and therefore alphabetically obvious) positions in the line-formula notation. A search for acyl chlorides illustrates this, as some 42 percent of the acyl chloride notations show -VG at the ending, rather than GV- at the beginning, of the notations. This search started with the 1536 cards in the alphabetized V-non-carbon category deck. These were inspected visually for notations beginning with GV-, and 116 cards were found and removed. The remaining cards were then searched mechanically for G by sorting for punch position 11 in column 3. About 250 cards were found. These were inspected visually for -VG groups, and 84 of the desired cards were found. This inspection required about 5 minutes. While the sorter was searching for G among the V cards, the initial GV- cards were inspected, and one beginning with GVN- (not an acyl halide) was found and removed. In this way 199 acyl halides were located in less than 10 minutes, despite the unfavorable circumstances of a two-symbol combination with nearly half not in initial positions in the notation.

The 199 acyl halide cards, still in alphabetical order by notation, were run through the tabulator for listing in this order. Then the cards were arranged mechanically by boiling point of the compound, in ascending order, and listed in this order. Next the cards were

Table 2. IBM code for searching chemical structure descriptions in Wiswesser notation. Capital letters are Wiswesser symbols. A hyphen after the symbol means "attached to" the atom or group shown. Figures in parentheses show the observed frequency of each category in 50,000 organic compounds.

Punch position	Presence of group is shown by punched position in		
	Column 3	Column 4	Column 5
12	G (chlorine atom), ionic or inorganic (2945)	QV (—COOH acids) (6940)	U (unsaturation)-carbon only; CC if equivalent to UU (5164)
11	G, all other chlorine (5548)	OV-two non-keto carbons (esters) (9204)	U-non-carbon (7014)
0	E (bromine atom) (4299)	OV-non-carbon or ionic or -keto carbon (1556)	WN (—NO_2 group)-carbon on resonating ring (6927)
1	F (fluorine atom) (397) I (iodine atom) (1753)	O-two non-keto carbons (ethers) (7219)	WN, all other -NO_2 W, not in WN or WS (447)
2	M (imido —NH—) -non-carbon or -keto carbon (not in MV) (2921)	O-one carbon only (aldehydes, quinones) (1241)	WS (in sulfonic acids, sulfones, etc.) (1964)
3	MV- or MVMV-non-keto carbons only (3961)	O-others (not in OV) (1331)	S (sulfur atom) not in WS (1407)
4	M (imino —NH—) -non-keto carbons only (3780)	Q-carbon in resonating ring (phenols) (6969)	X (four-branched carbon) (1758)
5	K (quaternary nitrogen) and N-keto carbons or -non-carbon only (899)	Q-other carbon (not in QV) (alcohols, enols) (3723)	Y (three-branched carbon) (12,015)
6	N-non-keto carbon only (7201)	Q-non-carbon or ionic (2980)	Other element: B, Si, P, As, Se, Te, and all metals (2068)
7	N-one or two non-keto carbons (not in WN) (6940)	V (keto carbonyl) -carbon only (ketones) (6138)	Extra punch for CN, CNO, CNS, NUN, K, OUR, VV, WN-alkyl (3128)
8	Z (amino, —NH_2)-carbon in resonating ring (3758)	V-non-carbon (not in QV, MV, or OV) (2917)	Extra punch for F, MM, MVMV, NN, OO, SS, UU (CC) (1729)
9	Z, all other —NH_2 (amino, amido) (5087)	MV- or MVMV-non-carbon or -keto carbon (2172)	

arranged by melting point of the compound, in ascending order. Cards for compounds with melting point below zero were removed by inspection and placed in proper "reverse" order. This third arrangement was listed. The cards then were sorted back into alphabetical order by notation and refiled manually with the other cards in the V-non-carbon deck, to be ready for future searches. This last operation can be done more rapidly if a collating machine is available. Nevertheless the entire searching, sorting, listing, and refiling operation to produce these three printed lists of 199 acyl halides took only 1 hour. Obviously the 5 minutes spent in visual inspection to find -VG combinations is not a significantly large part of the total time required.

Similar lists were prepared from the 24,700 compounds for 350 semicarbazones, 600 oximes, 120 acid anhydrides, 525 amides, and smaller numbers of imides and acyl bromides, with very similar findings relative to the amount of visual inspection needed and the total preparation time required.

Searches on 50,000 Compounds

When the catalog had been expanded to 50,000 compounds, another series of searches was tried with the techniques described above and the 1000-card-per-minute sorter which had become available. A semicarbazone search, previously mentioned, produced the cards for 1097 semicarbazones in 8 minutes, with only two unwanted cards. A more complex search produced simultaneously the cards for 420 phenylhydrazones, 50 *p*-bromophenylhydrazones, 230 *p*-nitrophenylhydrazones, and 250 2,4-dinitrophenylhydrazones, each in separate alphabetized groups ready for listing, in 25 minutes of machine sorting and 55 minutes of visual inspection. As a by-product of this search, the machine-sorts to remove thiosemicarbazones (by sorting for S, column 5, punch position 3 and Z, column 3, punch position 9) and phenylsemicarbazones (by sorting for MV, column 4, punch position 9) gave "pure products" in each of these categories without "contamination" either from compounds in the four groups being sought or from other compounds.

Summary

A method has been developed for locating data about organic compounds with similar functional groups by means of punched-card techniques on a standard IBM sorting machine. By a judicious combination of machine sorting (made possible by the searching code described above) and visual inspection (made possible by the intelligible nature of the Wiswesser notation), the use of expensive and complicated machines has been avoided. The Wiswesser notation makes it possible to locate individual compounds at once in alphabetically arranged lists or files of cards. The searching system described above makes it possible to locate compounds with similar functional groups among the 50,000 organic compounds currently in the punched-card file described, and many of these searches can be completed in a matter of minutes.

Printed lists of the compounds, with the complete line-formula structure and other data, have been prepared quickly and effectively with an IBM tabulating machine from the cards located in the search. The conciseness of the Wiswesser notation makes the system efficient, since the notation and data for a given compound may be carried on a single card, which can be used in a tabulating machine to prepare lists of notations and data directly (*6*).

References and Notes

1. M. M. Berry, "Non-conventional Technical Information Systems in Current Use" (National Science Foundation, Washington, D.C., 1958).
2. W. J. Wiswesser, *A Line-Formula Chemical Notation* (Crowell, New York, 1954).
3. I. Heilbron and H. M. Bunbury, Eds., *Dictionary of Organic Compounds* (Eyre and Spottiswoode, London, ed. 2, 1943).
4. W. J. Wiswesser, *Advances in Chemistry Series No. 16* (1956), p. 76.
5. In a printed note dated 11 May 1957, Wiswesser acknowledged these shortcomings by revising his own searching code into one that more closely follows the code described here.

6. I am grateful to the University of Hawaii, Honolulu, where this study was carried out, for a reduction in teaching load which made part of this work possible; to the College of Business Administration of the university for access to IBM equipment; and to John Ferguson and Tad Nakano for their patient help with machine problems.

Science in the News

Royal Society Celebrates Tercentenary

In 1960 the Royal Society celebrates the tercentenary of its founding. It was on 28 November 1660 that the decision was taken to form a society for the promoting of experimental philosophy, by a group of 12 remarkable men, including Lord Brouncker, Robert Boyle, Sir William Petty, and John Wilkins, who met after a lecture by Christopher Wren at Gresham College in the city of London.

Two years later, Charles II granted them a royal charter which gave the society its constitution and its name, "The Royal Society of London for Improving Natural Knowledge." Some of those who were present on foundation day had been meeting with other enthusiasts to discuss the new philosophy during the previous 15 years, first in London, then in Oxford, and later in London again, after 1658.

Oldest Scientific Society

The Royal Society is the oldest scientific society in the world with a continuous record of activity, and today it fulfills the functions of a British academy of sciences, with members drawn from most of the countries of the British Commonwealth. All the great names in British science are to be found in the annals of the society, and many of the world's most famous men of science are in the roll of foreign members. A close and friendly relationship with the scientists of other countries has been one of the features of the society from its earliest days.

Its original constitution recognized

the Royal Society as a completely independent body governed by its president and council and, unlike the French Academy, without any subsidy from the government. The names of some of its 17th-century presidents—such as Pepys and John Evelyn—show that the fellowship then included amateurs. Their interest and financial support were of great help to the society in those difficult early days. The amateurs continued to have a considerable influence on the affairs of the society until 1847, but since that date election to membership has been dependent on scientific merit and is a much-sought privilege.

As today's president, Sir Cyril Hinshelwood, has said, "the choice of its Fellows is in many ways the most important of the activities of the Society, just as Nature places the perpetuation of the species as a first charge on most of her business." In 1900, 15 fellows were elected each year, but the number has now been raised to 25. In 1958 there were 655 fellows, including 61 foreign members.

Contributions to Progress in Science

In looking back over the history of science since 1660 the society has every reason to be proud of the contribution of its members, particularly of the part they have played in many of the major episodes of scientific progress when some new break-through has changed men's outlook.

The names of Newton, Dalton, Faraday, Darwin, J. J. Thomson, and Rutherford are all associated with milestones in the progress of ideas. Less spectacular but perhaps no less important has been the steady contribution of the society throughout its life to the growing stream of scientific knowledge. And here it has played a notable part with its publications. The *Philosophical Transactions*, which was started in 1665, is the oldest of the existing scientific journals, and since 1832 an even larger volume of papers has been published in the *Proceedings*, one section of which appears every two weeks. The meetings of the society are devoted mainly to discussions of the papers submitted for publication and to symposia on topics of current interest.

Thanks to the bequests it has received and to regular government grants which the society is entrusted to administer, it is able to support the scientific publications of numerous societies, to endow a number of research appointments, and to make grants to support the work of scientific investigators. The administration of its funds and of its other activities is in the hands of a number of expert committees of the fellows, who deal with problems arising in their particular spheres and give advice to the government, when, as often happens, such advice is requested.

In the reign of Queen Anne the society was made responsible for supervising the work of the Royal Greenwich Observatory, a duty which it now shares with the Royal Astronomical Society; it also appoints most of the members of the governing body of Britain's National Physical Laboratory and has representatives on about 100 other public bodies. Recently it administered a large government grant in support of the British activities during the International Geophysical Year, including an expedition to Antarctica.

In addition, it carries responsibility for British participation in the field of international relations in science through its membership in various international unions which are members of the International Council of Scientific Unions. It also provides advice to the government on the natural sciences program for the United Nations' Educational, Scientific, and Cultural Organization.

However, in the words of the president, "Whatever the importance of its corporate activities, the most significant contribution it makes is simply the sum total of innumerable individual contributions made in very varied ways by the Fellows in their own right. They are, of course, free and independent agents, but the Society provides them with the means of publication, on occasion with financial help, and with an elaborate and sensitive mechanism for consultation and exchange of views on every kind of scientific matter. It constitutes in a way a kind of central nervous system of science in Britain."

The society's tercentenary celebrations will occupy a two-week period, starting 18 July. The opening ceremony and the president's tercentenary address will be in the Royal Albert Hall, London. The days that follow will be devoted to scientific lectures by a number of fellows and to social gatherings and visits to Oxford and Cambridge and other centers of interest. The celebrations will be attended not only by the fellows and foreign members but by delegates from national academies of science and from universities throughout the world.

HAROLD HARTLEY
Royal Society of London, London, England

Ford Foundation Aids New French Center for Human Sciences

The Ford Foundation has announced an appropriation of $1 million to strengthen the facilities and programs of a new Center for the Human Sciences being established in Paris. In addition to this appropriation in the social sciences, the foundation has awarded two grants to stimulate international cooperation in the natural sciences: $500,000 to the European Nuclear Research Center (CERN), Geneva, and $300,000 to Niels Bohr's Institute for Theoretical Physics, Copenhagen.

These actions were among several announced by the foundation to promote international understanding and to assist educational and research institutions in Europe, Asia, and the Near East. Others included: a $700,000 appropriation to expand facilities for receiving foreign visitors in Washington, D.C.; a grant of $750,000 to the Congress for Cultural Freedom, Paris, for international activities; and a $600,000 grant to the government of Pakistan for two pilot centers to develop rural industries.

French Center Described

Shepard Stone, director of the foundation's International Affairs Program, pointed out that the action of French authorities in establishing a new Center for Human Sciences in Paris reflects growing French interest in the social sciences. The center will group together institutes in international relations, anthropology, sociology, psychology, economics, geography, social mathematics, and statistics.

The French Government has budgeted $2 million to build the center and is providing additional funds for its operation and development. The Ford appropriation will make it possible for the center to draw on American and other foreign experts in developing its program, will help expand the center's library resources, and will finance fellowships for the exchange of research scholars with other countries.

The grant to CERN, the nuclear-research center supported by 12 European governments, will enable scientists, particularly from the United States and Asian countries, to participate in the high-energy experimental work at Geneva. The grant to the Institute for Theoretical Physics in Copenhagen will make possible an increase in the number of foreign scientists participating in its program. The foundation made

grants of $400,000 and $300,000, respectively, to these institutions in 1956.

The appropriation of $700,000 to strengthen facilities and organizations in Washington, D.C., concerned with the reception of foreign leaders, scholars, and students will be divided as follows: $500,000 will be used for the purchase and furnishing of a large estate, Meridian House, as headquarters for the Washington International Center, and $200,000 will assist agencies receiving nongovernmental visitors.

The Congress for Cultural Freedom, a world-wide organization of scientists, philosophers, and writers, received $750,000 to support for 3 years its program of international conferences, study groups, and exchange in Europe, Asia, Africa, and the Americas. The foundation made a grant of $500,000 to the congress in 1957.

The Pakistani government's pilot centers, one in West Pakistan and one in East Pakistan, will develop and demonstrate efficient small industries based on rural resources and skills. The new grant, which follows an earlier grant to the Stanford Research Institute to help plan the centers, provides for continuation of Stanford's advisory services and for equipment and training for Pakistani staff members.

U.S. Scientists Participate in International Space Symposium

Approximately 65 United States scientists participated in the first International Space Science Symposium that took place in Nice, France, 11–15 January under the auspices of COSPAR, the Committee on Space Research of the International Council of Scientific Unions. This country's participation in the symposium was coordinated by the Space Science Board of the National Academy of Sciences, which is the U.S. member of COSPAR. Scientists from universities, government laboratories, and private research organizations delivered 47 papers.

The symposium dealt with all scientific problems specifically connected with space science. Subject matter of the papers ranged from the earth's atmosphere to the possibilities of life on other planets.

A total of some 100 papers from nine countries were presented, and more than 250 persons from at least 17 countries participated in the meeting. Countries represented included Argentina, Australia, Belgium, Canada, France, the German Federal Republic, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, China (Taiwan), the Union of South Africa, the U.S.S.R., the United Kingdom, and the United States.

COSPAR was established in October 1958 to coordinate scientific research internationally in the field of rockets and satellites. National membership is open to all national scientific institutions adhering to ICSU that are actively engaged in space research. Nine International Scientific Unions also participate in COSPAR.

Virology Conference To Have Outstanding Participants

A conference on Perspectives in Virology will be held in New York at the Park Sheraton Hotel, 25–26 January. Symposium participants will include public health administrators and heads of schools of public health from every section of the United States and from Europe, Africa, Southeast Asia, Japan, South America, and Australia. The public health authorities are expected to make up more than a quarter of the invited audience of 125.

The list of foreign visitors to the meeting includes Alick Isaacs of the National Institute for Medical Research, London, who will report on the first antiviral substance to be found in human body cells, and Gerhard Schramm of the University of Tübingen, Germany, who will report on the transformation of viruses from one type to another. Seven Nobel Prize winners will take part in the symposium: John P. Enders, Harvard Medical School; Severo Ochoa, New York University; Frederic C. Robbins, Western Reserve University; Wendell M. Stanley, University of California; Max Theiler, Rockefeller Foundation; Sellman A. Waksman, Institute of Microbiology, Rutgers University; and Thomas Weller, Harvard School of Public Health.

The symposium is the second of a biennial series. The first meeting, held in February 1958, marked out several new areas for laboratory exploration. It also stimulated a new awareness, at the state and local levels, of the significance of work now going on in the field and led to expanded virus research programs in cancer and childhood diseases.

Gustav Stern, philanthropist and retired industrialist of New York, is the sponsor of the symposium. Stern also was responsible for the 1958 meeting and for two earlier meetings, on psittacosis, a virus disease of birds to which human beings are susceptible. Director of the symposium is Morris Pollard, professor of Preventive Medicine and Public Health at the University of Texas, Medical Branch, Galveston.

Graduate Fellowships Awarded under Education Act

The U.S. Office of Education has announced approval of 406 programs of graduate study involving 1500 3-year fellowships authorized by the National Defense Education Act. The fellowship awards, provided under Title IV of the National Defense Education Act, are for study at 136 graduate schools during the 1960–61 academic year. One thousand graduate students are already working under National Defense Fellowships that were awarded last May. A total of 5500 3-year fellowships are authorized under the Act over a 4-year period.

The programs that have just been announced were selected from 918 proposals submitted by 155 institutions which requested 5370 fellowships. A 12-member advisory committee of educators from colleges and universities and a panel of five consultants from graduate schools reviewed the proposals and made recommendations. All the approved programs lead to the doctoral degree and, as required by the act, either establish new or expand existing graduate facilities.

Most of the 123 institutions that participated in the graduate fellowship program last year received additional fellowships. Of the 406 programs just announced, 202 include new fellowship allotments for programs approved a year ago.

The 136 participating graduate schools will receive up to $2500 per year for the cost of educating each fellow. The fellow will receive $2000 for the first year of study, $2200 for the second, and $2400 for the third, together with an allowance of $400 for each dependent.

Graduate schools with approved programs will submit student applications for fellowships to the Commissioner of Education by 5 March. The awards will be announced shortly thereafter. All but 150 of the fellowships will go to students who have had no more than one semester of graduate study in the field in which they intend to earn their doctoral degree.

The graduate fellowship program is headed by Henry Bent, who is on leave from his position as dean of the graduate faculty and professor of chemistry at the University of Missouri.

News Briefs

Radiobiology. The third Australasian Conference on Radiobiology will take place at the University of Sydney in Australia, 15–18 August 1960. Titles of papers to be presented must be submitted before the end of February 1960 to the convener, Dr. Peter Ilbery, Department of Preventive Medicine, University of Sydney, New South Wales. Summaries (250 words) must be sent in by the end of March. Papers should be of radiobiological interest but they may cover the wide fields of biology, biochemistry, biophysics, genetics, immunology, radiation protection and health physics, and so forth.

* * *

Electron microscopy. Under the auspices of the International Federation of Electron Microscope Societies, the Nederlandse Vereniging voor Electronenmicroscopie is organizing a European Regional Conference on Electron Microscopy. The conference is to be held at Delft, 28 August–3 September. Information may be obtained from the secretary, A. L. Houwink, Julianalaan 67 A, Delft, Holland.

* * *

Physics students. The first student section of the American Institute of Physics composed entirely of women has been established at Smith College. The purpose of the sections is to encourage the study of physics and to develop professional pride and responsibility in those students who elect to become physicists. Typically, the sections sponsor talks in physics and other sciences, hold special meetings, and encourage the discussion of the role and scope of physics in our society.

Thomas C. Mendenhall, president of Smith, said: "We hope that this participation of our undergraduates in the new A.I.P. student section will help to explode the myth that there is little interest in studying physics among college women."

* * *

Indirect cost policy. In connection with its programs for the support of basic research, the National Science Foundation has followed the policy of permitting institutions to apply for and receive, as an indirect cost allowance, up to 15 percent of the total direct costs involved in approved grant proposals. Pending completion of a study of the entire problem of indirect costs, the foundation has announced that, effective 1 January 1960, it will permit institutions to request up to 20 percent of total direct costs as the allowance for indirect costs in approved research proposals.

Grants, Fellowships and Awards

Educational media. A new small-grants program to encourage graduate students and teachers to conduct research in educational uses of mass media in elementary and secondary schools, colleges, and universities has been announced by the U.S. Office of Education. The initial amount available will come from a total of $300,000 to be used for research grants between now and 30 June 1960 under Title VII of the National Defense Education Act.

The new program will provide an unusual opportunity for promising young researchers to engage in a year of exploratory studies. It is hoped that these studies will lead to projects of greater scope. The researcher may study methods for utilizing all or any of the media. These include motion-picture films, television, radio, recordings, filmstrips, language laboratories, and teaching machines. Applications for grants not to exceed $2500 should be filed *before 1 February* with the Educational Media Branch, Office of Education, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

General. The American Academy of Arts and Sciences invites applications for grants from its research funds. Awards are made in support of research in any field of science whatsoever, in amounts that ordinarily do not exceed $1500. Applications for grants to be made in the spring should be filed by *1 February* on forms that may be obtained from: The Chairman, Committees on Research Funds, American Academy of Arts and Sciences, 280 Newton St., Brookline 46, Mass.

Special consideration will be given to projects on new frontiers of science; to those that lie between, or include, two or more of the classical fields; and to those proposed by investigators who may be on the threshold of investigational careers or who are handicapped by inadequate resources and facilities. The committees do not provide fellowship or scholarship support, nor do they ordinarily approve grants for research the results of which constitute partial fulfillment of requirements for an academic degree.

Medical journalism. The Albert and Mary Lasker Foundation has announced the 11th annual Albert Lasker Medical Journalism Awards for outstanding medical news reporting in newspapers, magazines, and broadcasting during 1959. Stories, articles, and programs which dealt with the major killing or crippling diseases, and with public health problems in these same areas, should be submitted to the foundation (Chrysler Building, New York 17, N.Y.) *before 8 February*.

Each award includes an honorarium of $2500, an engraved citation, and a silver statuette of the Winged Victory of Samothrace (which symbolizes victory over death and disease). Three winners are customarily chosen each year on the recommendation of an advisory board of physicians and journalists.

Areas in which the foundation seeks especially to foster public understanding are heart disease, cancer, mental illness, arthritis, and neurological disease. Articles and scripts should demonstrate skill in arousing and holding the average person's interest. They will also be judged on the basis of accuracy, significance, timeliness, and proficiency in the transmission of technical information in lay language.

Miniaturization. Nominations for the 1959 Miniaturization Award competition will close on *20 January*. The award is presented annually in recognition of outstanding contributions to the advancement of the field of miniaturization. In addition to the top award, ten certificates of excellence are given each year. The competition was established in 1957 by Miniature Precision Bearings, Inc.

Participants may be individuals, companies, or organizations that have (i) broadened the horizons of miniaturization by creating better understanding and use of miniaturization through education, research, engineering, or standardization, or (ii) that have developed products, components, or assemblies which show ingenuity in the solution of miniaturization problems.

Selection is made by an independent committee of miniaturization experts representing industry, government, and education. Entries should be sent to the Miniaturization Awards Committee, Box 604, Keene, N.H.

Scientists in the News

John D. Sullivan, technical director of Battelle Memorial Institute, Columbus, Ohio, will receive the 1960 Albert Victor Bleininger Award of the Pittsburgh section of the American Ceramic Society on 11 March.

Norman A. Baily, former chief scientist of the radiation department at Roswell Park Memorial Institute, Buffalo, N.Y., is now senior staff physicist in the Hughes Aircraft Co.'s nuclear electronics laboratory.

Forrest Fulton of the University of London School of Hygiene and Tropical Medicine will complete a visiting professorship in virology at Baylor University College of Medicine this month. In addition to teaching, Fulton has done research on antigenic variation among the polioviruses.

Paulo Ribeiro de Arruda now directs the International Atomic Energy Agency's Division of Exchange and Training. A former professor of applied electricity at the Polytechnical School of the University of São Paulo, São Paulo, Brazil, Ribeiro succeeds **Joachim da Costa-Ribeiro**, also of Brazil.

J. P. Dailey has been named director of research in charge of biochemistry, organic chemistry, and pharmacology at the Armour Pharmaceutical Company laboratory. Replacing Dailey as head of the organic research department is **C. D. Bossinger**, a former research scientist. **J. W. Bastian** now heads the department of pharmacology.

C. N. Hugh Long, Sterling professor of physiology and chairman of the department at Yale University, received the 1959 Pharmaceutical Manufacturers Association Award for outstanding contributions to medicine on 8 December.

R. C. Merrill, the current director of clinical research in the medical division of the Squibb Institute for Medical Research, will become associate director of the Squibb research and development laboratories.

E. W. Rebol, director of the Hialeah Laboratory of National Spectrographic Laboratories, Inc., has been selected by the Atomic Energy Commission to become chief of the material branch, Industrial Office Division.

At the annual American Geographical Society dinner on 28 January, medals will be presented to three scientists.

Albert P. Crary, chief scientist for the U.S. Antarctic Research Project, will receive the Cullum Geographical Medal for geographical discoveries and for geophysical research in the polar regions.

Richard Hartshorne, professor of geography at the University of Wisconsin, will receive the Daly Medal for contributions to political geography.

William E. Rudolph, managing consultant of Dorr Consultants, will receive the David Livingstone Centenary Medal for his geographic research in the Southern Hemisphere.

Richard H. Jahns, professor of geology at California Institute of Technology, will become chairman of the division of earth sciences and professor of geology at Pennsylvania State University, effective 1 July. Jahns succeeds **O. Frank Tuttle**, now dean of the College of Mineral Industries. **Benjamin F. Howell, Jr.**, head of the department of geophysics and geochemistry, is serving as acting chairman.

Bostwick H. Ketchum, senior oceanographer at the Woods Hole Oceanographic Institution, has been named as a lecturer on the Harvard faculty. In addition to guiding graduate research, Ketchum will teach biological oceanography.

Albert E. Sobel will receive the fourth annual Van Slyke Award of the American Association of Clinical Chemists for his work in clinical chemistry, on 16 February. Sobel, who has directed the chemistry department of Jewish Hospital, Brooklyn, N.Y., since 1933, is a former president of the association.

The Armour Research Foundation of Illinois Institute of Technology has announced the promotions of **Roy R. Whymark** and **Mahendra S. Sodha.** Whymark was named supervisor of the acoustics section; Sodha was appointed senior physicist.

Valy Menkin, guest investigator at the Henry Phipps Institute of the University of Pennsylvania, was awarded the Pasteur Institute Medal last October while in Europe as a visiting professor under the Fulbright program. He also received a medal from the University of Liége, Belgium.

J. Herbert Taylor, Columbia University professor of cell biology, is discussing nucleic acid synthesis and chromosome duplication as a Sigma Xi national lecturer at 20 colleges and universities this month.

Recent Deaths

Charles L. Brown, Jersey City, N.J.; 60; dean and one of the founders of Seton Hall University College of Medicine; former dean of Hahnemann Medical College (1946–54) and Temple University Medical School; 4 Dec.

Oliver E. Buckley, Maplewood, N.J.; 72; retired board chairman of Bell Telephone Laboratories, Inc.; pioneer in high-speed submarine telegraph cables; formerly directed research in acoustics, electronics, photoelectricity, and magnetism at Bell; 14 Dec.

Arthur F. Coca, Oradell, N.J.; 84; professor of immunology at Cornell University (1910–42); medical director of Lederle Laboratories from 1931 to 1949; founder of the *Journal of Immunology*; 11 Dec.

Ralph E. Gage; Norwalk, Conn.; 70; director of research and development for the Olin Mathiesen Chemical Company from 1925 to 1945 and technical adviser to the company until his retirement in 1957; developer of chemical and textile bleaches; 8 Dec.

Clyde C. Hamilton, Old Bridge, N.J.; 69; research specialist in entomology, particularly on the insect pests of ornamental plants, at Rutgers University; 6 Dec.

Bernard S. Robbins, New York, N.Y.; 54; professor of clinical psychiatry at New York Medical College; leader in the movement to reintegrate psychoanalysis with medical education; 16 Dec.

Helen D. Sargent, Topeka, Kan.; 55; chief psychologist at Topeka Veterans Administration Hospital and recently a researcher in psychotherapy at the Menninger Foundation; originator of the Sargent psychological test; 25 Dec.

Paul C. Shedd, Glen Ridge, N.J.; 58; professor of electrical engineering at the Newark College of Engineering; former research scientist with Boeing Airplane Co. and Hughes Aircraft Co.; 1 Jan.

Gertrude B. Wertenbaker, New York, N.Y.; 63; chairman of the department of physics and astronomy at Hunter College since 1950; faculty member for 39 years; 18 Dec.

Book Reviews

Istoriia Akademii Nauk SSSR [History of the Academy of Sciences of the U.S.S.R.]. vol. 1, *1724–1803*. K. V. Ostrovitianov, Ed. Academy of Sciences of the U.S.S.R. Press, Moscow, 1958 (in Russian). 483 pp.

During the 17th century Russia had neither secular schools nor scientific centers. The religious academies in Kiev and Moscow had a monopoly on the search for "higher knowledge" which consisted of sporadic efforts to interpret the tenets of Eastern Orthodoxy in terms of scholasticized Aristotelian philosophy. The great physical synthesis, crowning the scientific achievements of such 17th-century giants as Galileo, Kepler, Descartes, and Newton, did not produce even a feeble echo in Russia. It is doubtful whether any printed presentations of Copernicus' heliocentric ideas were available in Russian before the translation of Varenius' *Geographia generalis* in 1718.

Peter I, who gave a healthy impetus to the growth of scientific thought in Russia, worked on several fronts with varying successes. First he founded several secular schools, such as the Moscow school of mathematics and navigation (1701), which in 1715 was transferred to St. Petersburg and renamed the Naval Academy. He also organized several medical schools and so-called ciphering schools in the provincial capitals. Peter sponsored and guided various scientific projects; for example, he was responsible for the preparation of a map of the Caspian Sea for the Paris Academy of Sciences and for the dispatch of D. G. Messerschmidt to Siberia to look for medical herbs and to make a preliminary survey of the natural resources. Thousands of books confiscated in the Baltic states provided a nucleus for the establishment of the first Russian public library in 1714 which subsequently became the library of the Academy of Sciences. In 1719 the Chamber of Curiosities (*Kunstkammer*) was opened in St. Petersburg, and it soon became an unusually rich museum of natural specimens and ethnographic material. Peter also sponsored an ambitious translation project: many Western books on engineering, astronomy, and general scientific topics were published in the newly instituted civic script (used for the publication of secular books—that is, books not subject to Church censorship). Peter's last contribution in the field of scientific and educational endeavor was the founding of the St. Petersburg Academy of Sciences, which began to function in 1725, several months after his death.

The history of the St. Petersburg Academy from 1724 to 1803 is the subject of this bulky volume, written by some 25 experts in the history of science. The work on this book was started in 1949, the year in which the Communist party's attack on "cosmopolitanism" had reached its peak. The original intention of the editors was to produce a volume showing the "national character" of "Russian science" and the Russian priority in many scientific discoveries. The original manuscript, which apparently echoed this philosophy, was discarded, and the present volume was prepared under the guidance of a new group of editors, who have succeeded in producing a comparatively sober and documented study.

The Academy was founded after careful and painstaking preparations made by Peter and a small group of his advisers. During his Western trips, Peter became acquainted with the organization and activities of the Royal Society in London and the Paris Academy of Sciences. He also consulted Leibniz, Christian Wolff, J. N. Delisle, and Fontenelle. While most of his Western advisers urged him to abandon the idea of a high forum dedicated exclusively to scientific research and to concentrate on founding a university, Peter decided to combine the two. The new Academy was in a way a cultural paradox. Russia was not in a position to supply the new institution with learned members; the country could not even supply students for the academic university. Thus not only the first scholars but also the first students were imported. The Russian educational system was a pyramid standing upside down: its top was built before its base.

During the period covered by this book, the Academy had a total of 111 members (including the regular members and the "adjuncts"): 85 foreigners and 26 Russians. For a long time it was viewed by the government with pronounced disfavor, by the Church with a great deal of suspicion, and by the country's semiliterate gentry with open disdain. In the beginning it was a part of Russia's body politic, but not an organic component of Russia's culture. The process of its integration into Russian culture was painfully slow and was not completed before the 1860's.

From 1724 to 1803, according to the authors of this book, the Academy passed through three distinct phases. The first phase (1724–41) was dominated by administrative absolutism and bitter strife between so-called German and Russian factions. However, with the help of its library, press, and several museums and laboratories, the Academy immediately became a going concern. The *Commentarii*, the Academy's scholarly publication, reached every intellectual center of Europe. Among the members during this period were such great names as Daniel Bernoulli, the founder of modern hydrodynamics, and Leonhard Euler, one of the 18th century's most illustrious mathematicians. During the same period, J. N. Delisle became the country's first defender of the heliocentric system and a champion of a mathematical approach to astronomical questions.

The second phase (1742–65), during which Euler was a member of the Berlin Academy of Sciences, saw the rise to prominence of Mikhail V. Lomonosov, whose limitless energy earned him honors in many fields of intellectual endeavor. Because his ideas, fraught with Cartesian philosophy, were quite complex and some of his key papers were available only in manuscript form, Lomonosov's contemporaries did not fully appreciate his acumen and contributions. In his scientific work he combined daring specula-

tion with meticulous experiment. He worked on such diverse scientific questions as the conservation of matter, atmospheric electricity, the origin of icebergs, the composition of the earth's layers, and the origin and distribution of minerals in Russia. His interest went far beyond the limits of natural science: he argued eloquently against the Norman theory of the origin of the first Russian state, wrote tragedies on direct orders from the imperial court, and prepared papers on demographic questions and on the improvement of crafts, industries, and agriculture in his native land.

During this period the Academy's internal conflict grew unchecked, many foreign scholars left Russia, and the recruitment of new scientists with established reputation became an extremely difficult assignment. The Academy's first charter, promulgated in 1747, ignored Peter's intention to grant this institution the right "to rule itself" and made it an agency of the central government; the Assembly of Academicians was *de facto* subordinated to the academic office which was in the hands of appointed officials who often had little respect for scientific work. Despite all these difficulties, the Academy became an institution with firm roots. An impressive list of foreign scholars were elected corresponding and honorary members, and the ties with the learned societies of Western Europe made intellectual relations between the East and the West a two-way traffic.

The third phase (1766–1802), which began 1 year after Lomonosov's death and in the year of Euler's return to St. Petersburg, saw a comparative increase in the ratio of Russian scholars: of 40 newly elected academicians and "adjuncts," 14 were Russians. The work of the Academy was dominated by two major scientific concerns: the continuation of Euler's work in mathematical analysis and the large-scale natural-scientific expeditions to various parts of Russia during the late 1760's and early 1770's. After his return to St. Petersburg, Euler completed some 300 papers; in this he was helped by N. Fuss and other students. At the time of his death in 1783, eight members of the Academy were his disciples. They wrote on various topics in mathematical analysis and astronomy, translated several of Euler's works into Russian, and worked on the mathematical curriculum for the newly founded primary and secondary public schools. They played an important part in the building of a great mathematical tradition in Russia. The natural-scientific expeditions, dominated by an empirical-descriptive approach, produced large quantities of valuable geographical, geological, botanical, zoological, and other information. P. Pallas' *Travels in Various Provinces of the Russian Empire*, published in German in 1771–73, was soon translated into Russian, French, and English.

In the course of this period, the Academy ceased to be the country's only scientific institution. The University of Moscow, founded in 1755, began to assert itself by the end of the century, although on a very small scale. Various government departments sponsored and participated in special research projects. This was particularly true for the medical, mining, and commerce departments which were active in natural-scientific expeditions. In 1765 the Free Economic Society was established; it conducted research in various natural sciences related to agriculture and regularly published its *Works*. In 1783 the Russian Academy was founded and immediately undertook an intensive study of language and literature. In all these research bodies the influence of the Academy of Sciences was paramount. Paradoxically, as a reaction to the ideological influences of the French Revolution, Paul I assigned the Academy the unenviable task of serving as the chief censor of books imported from the West. This censorship, which was strictly applied for a short time, kept from Russia not only the books espousing the political ideas generated by the French Revolution but also those dealing with many natural-scientific topics.

While this book contains much information and is an important contribution to the intellectual history of 18th-century Russia, it has a number of rather obvious shortcomings.

The authors have made no effort to hide their nationalist bias. All Russian scholars are treated in tender terms and are pictured as saints unsusceptible to ordinary human frailties. On the other hand, Russia's foreign scholars are seen as mere human beings, many of them honest and dedicated, but most of them, including Euler, subject to human weaknesses.

The role of Lomonosov has been blown so much out of proportion that the total picture of the growth of scientific thought in 18th-century Russia has been somewhat distorted. Despite the magnificient compass of Lomonosov's genius, his influence was actually one-sided: he provided a much-needed inspiration to the sparse ranks of Russian scientists, but he did not influence their scientific interests and their theoretical and methodological orientations. Neither of the two general scientific concerns of the Academy—mathematical analysis and the empirical-descriptive study of the country's natural resources—was a continuation of Lomonosovian tradition.

The authors have not explored adequately the changing attitudes of various social classes toward science, the philosophy of Catherine II's enlightened absolutism, the impact of educational policies on scientific work, or in general, the nature of the conflict between official ideology and the theoretical orientations and aspirations of individual sciences. They have thrown only partial light on the multiple forces which influenced the growth of scientific attitude as a part of Russian culture.

ALEXANDER VUCINICH
Department of Sociology and Anthropology, San Jose State College

Virus Hunters. Greer Williams. Knopf, New York, 1959. xix + 503 pp. Plates. $5.95.

The effective science popularizer has to surmount the double hurdles of factual accuracy and alluring presentation. In *Virus Hunters*, Greer Williams manages to mount both these barriers in telling what he describes as possibly the biggest "double take" in the history of medical science. He recites first the story of the classical microbe hunters, starting with Edward Jenner, and then the exciting activities of virologists in recent decades.

Williams retraces the drama told by Paul de Kruif in *Microbe Hunters* (1926), but adds to the story the research work of such people as Wendell M. Stanley, Ernest W. Goodpasture, Thomas Francis, Jr., Max Theiler, Richard E. Shope, John F. Enders, Jonas E. Salk, Albert B. Sabin, and Heinz Fraenkel-Conrat.

Aware (as he points out in his book) that many physicians felt that de Kruif, an ex-bacteriologist, was "a popular medical writer who too often went overboard," Williams tries to curb some of

his enthusiasm for promising leads when he discusses such ideas as a possible cure for the common cold and the speculation that viruses may cause cancer.

Typical of his restraint is this quotation from the chapter on the latter subject: "One thing that sensational headlines do not tell us, but the experienced know full well, is that any bold, unqualified announcement of a 'new cure' for cancer is a good sign that the source may be a charlatan, a crank, or a fool. It hardly matters which—the statistics are all against the claim proving true. Somewhat the same thing applies to assertions about the exact cause or causes of cancer, but in a lesser degree."

Yet *Virus Hunters* is bright and readable. Williams, a newspaper and magazine writer, former public relations director for the American College of Surgeons, and director of information for the Joint Commission on Mental Illness and Health, includes some of the very human, personal background of contemporary virologists. All this is a dramatic and often exciting story, and that is how Williams tells it.

He points out (and I think he proves his point with this book) that such data are of some importance to the understanding of scientists as human beings, even if they may not be too important to the public's understanding of science itself. Many science writers and some scientists would argue even this last point.

HILLIER KRIEGHBAUM
Department of Journalism, Communication Arts Group, New York University

We Come from the Sea. Hans Hass. Translated by Alan Houghton Brodrick. Doubleday, New York, 1959. 288 pp. Illus. $6.50.

The numerous books on skin-diving which have appeared in recent years may be roughly divided into several classes—those dealing with barren records of depth descents, others telling of hair-raising adventures with giant octopi, barracudas, and sharks, and still others devoted to the unsportsmanlike slaughtering of shore fishes to record their numbers and size. Another rather small group contributes lasting value to our knowledge of undersea life. The present volume may be accorded a different main objective—the presentation of outstanding photographs together with a creditable number of scientific facts.

In the search for photographic material, Hass admits that "Our first and foremost preoccupation on all our expeditions was with sharks and other marine creatures that are ready to attack. This was a matter for ourselves as well as for other scientists to whom we wanted to recommend our diving methods as useful for research." As a result, lovers of excitement will find much that appeals to their taste in this conservatively written book. The experiences vary from an encounter with a 5-foot brown shark, which severely wounded the diver, to the prolonged investigation of a 25-foot whale shark, which permitted all kinds of intimacies including the taking of closeup underwater photographs from all angles. I can testify to these extremes of shark psychology. Hass considers that blood in the water or attempts to escape by swimming rapidly away are most likely to induce a shark to attack. He believes that noise is an effective way to frighten sharks.

Much of the work was done with the aid of a 140-foot, three-master schooner, the *Xerifa*, fitted with dynamos, sound-recording instruments, and complete photographic and skin-diving equipment. Much of the latter was invented by the author.

The volume is a pleasant running account of the activities of several expeditions that ranged from the Red Sea and the Caribbean to Galapagos and the Great Barrier Reef. Among the scientists on these expeditions was I. Eibl-Eibesfeldt, whose studies of the Galapagos sea-lions are touched upon. Serious scientific work was also carried on at the Dutch island of Bonaire; this work included an investigation of the toxic effects on marine life of various paints on the ship's bottom, and observations on the responses of fish to mirrors and on their territorial behavior.

The chapter "We go back into the sea" provides an excellent résumé of the history of skin-diving. The list giving the names of fishes and birds mentioned is of little use, but both the bibliography and the index are good. The illustrations, of which ten are in color, are of unusually high quality, and take up about one-third of the book. There are three maps.

WILLIAM BEEBE
Trinidad Field Station, New York Zoological Society

The Population of the United States. Donald J. Bogue. With a chapter on "Fertility" by Wilson H. Grabill. Free Press, Glencoe, Ill., 1959. xix + 873 pp. Illus. $17.50.

The massive magnitude of this demographic catalog of contemporary America and its consequent utility as a reference source can readily be documented by statistics about the production. The book contains 26 chapters delineating the major variables of population structure and process, furbished with 385 substantial, numbered tables and 92 well-designed figures, as well as several hundred smaller tables inserted directly into the text; the text itself is a document of a quarter of a million words. The appendix consists of 68 full-page summary tables, and 90 pages are devoted to detailed data on occupation and industry. In short, no opportunity has been lost to display the host of research potentialities and policy implications which might otherwise languish unsighted within our national statistical system.

The list of contents is closely keyed to the kinds of socioeconomic data yielded by official enumeration and registration procedures; particular emphasis is placed on spatial distribution and economic characteristics; this is cross-classified by the conventional demographic control variables. Supplementary chapters based on diverse sources provide data concerning illness, religion, housing, and the populations of Alaska and Hawaii. The latter information is particularly welcome since it conveniently obviates for the analyst the nuisance of referring to otherwise scattered materials.

Bogue's book is useful in different ways, which I am confident will assure it wide distribution for a long time. Its most obvious utility is as a rich reference source, particularly for nonprofessionals working in applied fields. For this reason it is regrettable that the production is marred by an excessive number of trivial mistakes which tend somewhat to reduce the confidence with which the data can be used. More serious is the criticism that, in common with government analysts, the author has underemphasized the analytic relevance of errors of misstatement and misenumeration in officially published data. The book also has considerable virtues as a textbook, or at least teaching supplement, despite its almost prohibitive price for this particular market. From the

standpoint of this use, the omission of anything approaching an adequate bibliography or reference to other research is most unfortunate. It is particularly puzzling that Bogue does not mention either the census monograph by the Taeubers (its chapter outline almost parallels his own) or that by Duncan and Reiss (on rural and urban communities)—especially in the light of his major emphases.

Finally, judged as a research contribution in its own right, the book varies considerably in quality from topic to topic. This comment is, I admit, uncharitable in view of the aggregate magnitude of the tasks attempted. The treatment is outstanding where Bogue deals with spatial distributions and agglomerations, but falters in areas of analysis where he has had less experience—for example, in the vital processes and in the interrelations of demographic and economic development. It is, nevertheless, unquestionable that Bogue has produced a most impressive array of research suggestions, guides, and assistance, and the fields of pure and applied demography should be properly appreciative of this.

NORMAN B. RYDER
Department of Sociology,
University of Wisconsin

Dana's Manual of Mineralogy. Revised by Cornelius S. Hurlbut, Jr. Wiley, New York; Chapman and Hall, London, ed. 17, 1959. xi + 609 pp. Illus. $11.50; textbook edition, 9.50.

This new edition of one of the oldest textbooks of mineralogy has been extensively rewritten, rearranged, and enlarged. It is 79 pages longer than the previous edition, but the new material exceeds 100 pages, since some sections, especially that on mineral uses, have been drastically cut. New features emphasized in the preface are: (i) a section on stereographic projection (10 pages) together with half of a Wulff net of 10-cm radius on the inside back cover; (ii) the inclusion of all the 32 crystal classes in the systematic discussion of morphology; (iii) a section (10 pages) on calculation of axial ratios (which ought to have dealt with axial *elements*); and (iv) 22 pages on x-ray crystallography.

Unfortunately, no reference to axial elements, interfacial angles, or cell dimensions is to be found in the descriptive part of the text. This is a serious lack, and limits the value of some of the new sections. Welcome as they are, these new sections are not without faults. The brief discussion of rules for crystal orientation, which precedes the section on calculation of axial ratios, seems to be intended only for the guidance of students in exercises with crystal models, and scarcely touches upon the real problems. A number of errors have crept into the new part on x-ray crystallography. The formula (page 139) for determination of the identity period from a rotation pattern is incorrect, and a very bad example is given to students by the reproduction of something in Figure 354 that should be frowned upon by all good mineralogists—an unindexed powder diffraction pattern. The American Society for Testing Materials' card for quartz reproduced in this figure was deleted from the ASTM file years ago. Moreover, it can readily be seen to be faulty if it is compared with the excellent photographic quartz diffraction pattern shown in Figure 356.

Parts of the chapter on descriptive mineralogy remain unchanged from the previous edition. Some of the chemical formulas of minerals, such as that of colemanite, have not been brought up to date as they should have been. The newly inserted statement that "chrysoberyl has a puckered structure of lower symmetry than the spinels" fails to illuminate the very interesting structural relations. The unchanged treatment of limonite seems curious in a text that has been modernized to a large extent, and the use of the name *turgite* (pages 306 and 317) as though it were a valid species designation is astonishing. However, much of the descriptive chapter has been improved. About 20 fine photographs of crystal structure models have been inserted, and the treatment of the silicates has been thoroughly revised, with a new order of presentation and increased emphasis on structural relations, especially those of the phyllosilicates.

A. PABST
Department of Geology,
University of California, Berkeley

New Books

Aircraft and Missiles. D. M. Desoutter. De Graff, New York, 1959. 220 pp. $7.50.

Amino Resins. John F. Blais. Reinhold, New York; Chapman and Hall, London, 1959. 231 pp. $4.95.

Biennial Review of Anthropology, 1959. Bernard J. Siegel, Ed. Stanford Univ. Press, Stanford, Calif., 1959. 281 pp. $6.

Chemicals, Drugs, and Health. John H. Foulger. Thomas, Springfield, Ill., 1959. 110 pp. $4.25.

Chemistry of Nuclear Power. J. K. Dawson and G. Long. Philosophical Library, New York, 1959. 216 pp. $10.

Darwin's Biological Work. Some aspects reconsidered. R. P. Bell *et al.* Cambridge Univ. Press, New York, 1959. 356 pp. $7.50.

Les Destins de la Vie et de l'Homme. Controverses par lettres sur des thèmes biologiques. H. Laborit and P. Morand. Masson, Paris, 1959. 249 pp. F. 1800.

Electrical Impedance Plethysmography. The electrical resistive measurement of the blood pulse volume, peripheral and central blood flow. Jan Nyboer. Thomas, Springfield, Ill., 1959. 260 pp. $7.50.

Elementary Biochemistry. Edwin T. Mertz. Burgess, Minneapolis 15, Minn., 1959. 300 pp. $6.50.

Fluid Dynamics. D. E. Rutherford. Oliver and Boyd, Edinburgh; Interscience, New York, 1959. 235 pp. $1.95.

The Fluids of Parenteral Body Cavities. Paul D. Hoeprich and John R. Ward. Grune and Stratton, New York, 1959. 102 pp. $4.75.

Foundations of Aerodynamics. A. M. Kuethe and J. D. Schetzer. Wiley, New York; Chapman and Hall, London, ed. 2, 1959. 460 pp. $11.75.

German-English Science Dictionary. Louis De Vries. McGraw-Hill, New York, ed. 3, 1959. 603 pp. $7. From the preface: "This dictionary has again been revised to include over 3000 new terms and newly recognized translations of terms that have become important in scientific literature since the end of the Second World War. These new entries, for the sake of expedience, are placed at the back, following the Appendix."

German Secret Weapons of the Second World War. Rudolf Lusar. Translated by R. P. Heller and M. Schindler. Philosophical Library, New York, 1959. 280 pp. $10.

A Guide to the Identification of the Genera of Bacteria. With methods and digests of generic characteristics. Based on data given in ed. 7 of *Bergey's Manual of Determinative Bacteriology* and on original papers. V. B. D. Skerman. Williams and Wilkins, Baltimore, Md., 1959. 226 pp. $5.50.

Handbook of South American Indians. vol. 7, *Index*. Bureau of American Ethnology, Bull. No. 143. Smithsonian Institution, Washington, D.C., 1959 (order from Supt. of Documents, GPO, Washington 25). 292 pp. $2.

Homotopy Theory. Sze-Tsen Hu. Academic Press, New York, 1959. 360 pp. $11.

Introduction to Colloid Chemistry. Karol J. Mysels. Interscience, New York, 1959. 490 pp. $10.

An Introduction to the Kinetic Theory of Gases. Sir James Jeans. Cambridge Univ. Press, New York, 1959. 311 pp. Paper, $2.95.

An Introduction to Plasticity. William Prager. Addison-Wesley, Reading, Mass., 1959. 156 pp. $9.50.

Introduction to Quantum Mechanics. Chalmers W. Sherwin. Holt, New York, 1959. 397 pp. $7.50.

Reports

Induction of Fechner Colors in Black and White Photographs

Abstract. Fechner colors are visible when two black and white photographs of a scene which have been taken with long-wavelength and short-wavelength light, respectively, are viewed in an alternating sequence. Such colors may be combined with spatially induced, two-primary colors to enhance or reduce the vividness of the latter.

Several recent publications by Land (*1*) have attracted considerable attention to situations in which colors which include a broad range of hues can be discriminated in projected photographs, even when the spectral composition of illumination is restricted to two narrow wavelength bands which are quite close in the spectrum. The method consists of viewing two photographs, one of which has been taken with long-wavelength (red) light and the other with middle-wavelength (green) light, when these are projected, in register, on a screen. When the projection illumination of the photograph made with red light is restricted to relatively long wavelengths and that of the other to relatively shorter wavelengths, the colors of objects in the picture show a striking correspondence in hue to the colors of the same objects viewed directly in white illumination. The phenomenon is an old one and was reported as early as 1897 (*2*). Land's primary contribution has been to explore in some detail the range of spectral distributions which can be used.

These color phenomena may be attributed to simultaneous contrast, or spatial interaction, since colors can be perceived in short flashes during which adaption effects or afterimages cannot be expected to have any influence. The perceived colors cannot be attributed to the observer's "expectations" based on familiarity with the objects portrayed. Radical changes in hue are perceived when the long- and short-wavelength illuminations are interchanged, and these changes are readily perceived in 0.01-second flashes. Land himself has employed the flash technique to demonstrate the immediacy of perception of the colors with a stereo shutter which is mounted on a pair of goggles.

There is another method, quite different from the method which has been employed by Land, by which colors may be induced with hues which do not bear the usual relation to the spectral character of the illuminant. This method, which involves temporal induction, was reported as early as 1826 (*3*). It gives rise to the so-called Fechner colors. One example of the method consists of illuminating an area of the retina in various temporal sequences with a homogeneous dark stimulus, a homogeneous light stimulus, and a pattern of lines on a light background (Benham's Top). It occurred to me that the kind of transparencies employed by Land might yield sensations of color if they were viewed in an appropriate temporal sequence when illuminated with white light.

A variety of temporal sequences was investigated. Colors could be perceived in transparencies which were viewed successively in the following manner: A disk chopper is so arranged that white light from the transparency which was photographed through a green filter first stimulates the eye. Immediately upon termination of this stimulation the eye is stimulated by white light from a transparency photographed through a red filter. This stimulation is followed by a dark interval approximately equal in duration to the total interval during which stimulation occurred. The cycle is then repeated. At a rate which produces noticeable flicker, objects in the picture assume colors of very low saturation which correspond approximately in hue with the colors of the original objects. Although relatively unsaturated, the colors are identifiable by the majority of observers. If the cycle is reversed by reversing the direction of rotation of the chopper, there is a change in the apparent colors. Formerly reddish objects appear greenish or bluish and formerly greenish objects appear pink.

It is possible to combine the Fechner colors with spatially induced, two-primary colors by locating long- and short-wavelength filters in the viewing system such that the two transparencies are illuminated with long and short wavelengths, respectively, instead of white light. When the direction of chopper rotation is such that the hues of Fechner colors correspond with those of the objects photographed, the two-primary colors are enhanced noticeably at rotation rates which produce flicker. This enhancement effect disappears when the rotation rate is increased to a point where there is no obvious flicker. If the direction of rotation is reversed, the vividness of the two-primary colors may be reduced at rates which produce flicker to the point where they disappear. As the rotation rate is then increased to a point where flicker disappears, the two-primary colors gradually emerge.

It would appear that spatial and temporal interaction effects in the retina which give rise to the perception of hues not ordinarily associated with the spectral distribution of the stimulating light are sufficiently distinct in their mediation to inhibit or enhance each other. These observations may afford new avenues of approach toward an understanding of the physiological bases of color perception.

JOHN LOTT BROWN*
Department of Physiology, School of Medicine, University of Pennsylvania, Philadelphia

References and Notes

1. E. H. Land, *Proc. Natl. Acad. Sci. U.S.* **45**, 115, 636 (1959); *Sci. American* **200**, No. 5, 84 (1959).
2. A. Ducos du Hauron, *La triplace photographique des couleurs et l'imprimerie* (Gauthier-Villars, Paris, 1897).
3. B. Prevost, *Mém. soc. phys. et d'hist. nat. Genève*, 3, 121 (1823–26); J. Cohen and D. A. Gordon, *Psychol. Bull.* **46**, 97 (1949).

* Senior research fellow, U.S. Public Health Service.

31 December 1959

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title, it should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Value of X-ray Films of Hand and Wrist in Human Identification

Abstract. As seen in the x-ray film, the individual bones of the hand and wrist differ sufficiently in form from one person to another so that such films can be valuable aids in establishing personal identification in either the living or the dead.

The difficulties experienced in Korea and elsewhere in attempting to identify the interred remains of servicemen which were unaccompanied by identification tags and which had no distinguishing dental or other features em-

phasized the need for some additional means of determining the identity of human skeletal remains. On the basis of rather extensive experience in working with x-ray films of the hands and wrists of children and adults, I had gained the impression that the various skeletal features visible in the posterior-anterior radiograph of the hand and wrist might be found to differ sufficiently from one person to another to permit identification of individuals from these alone. This report summarizes the results of an attempt to determine the usefulness of those radiographic features for this purpose (*1*).

It was established that, as seen in the posterior-anterior radiograph, the various bones of the hand and wrist show individual differences in form and in other features which, in the aggregate, are sufficient to distinguish the radiograph of the hand of one person from that of another. To begin with the ends of the radius and ulna and proceed distally, these features are: (i) the shape and relative size of the distal end of the radius and of the styloid process of the ulna; (ii) the shape of the individual carpal bones; (iii) the size and shape of the individual metacarpals, the relative width of their cortices and medullary cavities, and the individual differences in the outline of the inner margin of the cortex (that is, the margin immediately adjacent to the medullary cavity); (iv) the shape and position of the irregular white lines visible in the heads of the metacarpals; (these lines are composite shadows to which parts of the volar and dorsal surfaces and structures lying between them make variable relative contributions); (v) the differences in the shape and relative dimensions of the individual phalanges; and (vi) the fine details of trabecular pattern visible in the shafts of the various bones, especially in the proximal and middle phalanges.

A study of a series of radiographs of the hand made at regular intervals on the same individuals, from early childhood over a long period of years, disclosed that the skeletal features which are useful for individual identification usually become established during late adolescence and remain relatively unchanged until at least well into the thirties, the age of the oldest men on whom such film series were available to us. Since, however, the same features were observed in radiographs of the hand of several hundred men and women who were in their seventies and eighties, it is thought that most of those features remain recognizable throughout the life of the individual, even though they occasionally become modified somewhat by changes associated with aging.

In the radiograph of the hand and wrist, 27 complete bones and parts of two other bones (the distal ends of the radius and ulna) are visible. Since most of these possess a number of structural features which can differ from one person to another, the chance that radiographs of the hands of any two persons will be identical in all of these features would seem to be very small—if, indeed, such identity ever occurs.

Harold E. Jones, director of the Institute of Child Welfare of the University of California at Berkeley, kindly permitted me to study radiographs of the right and left hands of 70 pairs of like-sexed twins on whom he had previously made some other observations. Approximately 40 of these pairs appeared to be identical twins. While there was a very striking resemblance between x-ray films of the hand of the two members of each presumably identical pair, there were in every instance some features which made it possible to distinguish the hand and wrist bones of one person from those of his or her twin. The over-all similarity was so great, however, and our observations were so few, that we ought not ignore the possibility that skeletal features which we have found adequate to distinguish between radiographs of the hand of unrelated persons and of ordinary siblings are, in some instances, not sufficiently discriminating to distinguish an x-ray film of the hand of one identical twin from that of the other member of the pair. However, as mentioned above, no such instance was encountered among the cases which we were able to study.

In about 500 of the young men whom we x-rayed, separate radiographs were made of both the right and the left hand. Though, as might be expected, an individual bone of one hand or wrist is not always identical in form with the corresponding bone of the other side, it was found that there was a sufficiently close over-all similarity in the shape and proportions of the bones of the two hands to permit successful pairing of the two films of the same man when all identifying marks had been covered and the films were studied in a random order. It should, therefore, be possible to identify skeletal remains in which the bones of the forearm, wrist, and hand of only one side are present, by comparing the radiographic features of these bones with those visible in an x-ray film which had previously been made of the same or of the opposite side.

It might be thought that the ease with which the radiograph of the hand of one person can be distinguished from that of another in our population may, to some extent, be due to the heterogeneity in race and in national antecedents of the people of the United States. Our study of films of the hands of several hundred Apache Indians from the White River Reservation in Arizona and of a larger number of American-born Japanese living in California established, however, that the same individual differences in the skeletal features which we had observed in the more heterogeneous white population in our country exist also among American Indians and Japanese. Radiographs of the hand can, therefore, be used satisfactorily for purposes of individual identification within those groups and, presumably, among other racial groups as well.

These findings demonstrate that it is quite possible to establish the identity of an individual from the skeletal features visible in an x-ray film of his hand and wrist. Since many of those features remain relatively unchanged even after years of burial, the films could also provide conclusive proof of the identity of persons in whose remains other identifiable features are lacking.

WILLIAM WALTER GREULICH
Department of Anatomy, Stanford University School of Medicine, Stanford, California

Note

1. This investigation was supported by the Department of the Army through contract No. DA 19-129-QM-816.

26 August 1959

E[illegible]onmicroscopy of Dental Calculus

Abstract. Electron microscopy of ultrathin osmium-fixed sections of dental calculus, cut with a diamond knife without prior decalcification, revealed densely mineralized areas entrapping many degenerating microorganisms, within which were deposited similarly electron-dense crystals. Two principal forms of crystals were found, the predominant type being of the same order of magnitude and shape as those found in bone, and showing the typical characteristics of apatite in selected area electron diffraction patterns.

At present it is not possible to propose a single mechanism sufficiently inclusive to explain calcifiability of such diverse structures as endoskeletons, exoskeletons, teeth, kidney stones, or pearls, to name but a few of many normal and pathological types of calcification in biological systems (*1*). The most attractive conceptual scheme hitherto suggested to account for mineral deposition in vertebrate hard structures of mesodermal origin has evolved from the electron microscopic observations by Robinson (*2*) and Robinson and Watson (*3*), who studied adult human bone and dentin; by Jackson and Randall (*4*),

who examined embryonic avian bone; and by Glimcher *et al.* (*5*), who employed an in-vitro system of reconstituted mammalian collagen immersed in metastable phosphate solutions. According to these studies, a precise relationship was found to exist between the ultrastructural axial periodicity (640 A) of the native collagenous fibrous framework and the initial nucleation and ultimate orientation of the apatite crystal lattice.

The present study deals with a calcifiable biological system in which the deposition of bonelike crystals is demonstrated in a matrix independent of the cellular activities and fibrous protein synthesis of skeletal and dental organs, namely, the highly mineralized concretions known as dental calculus, or tartar, deposited within the oral environment on the external exposed surfaces of human teeth.

Recently accumulated concretions of supragingival dental calculus were collected from the lingual surface of the anterior teeth of adult patients who tended to form such deposits repeatedly within a week or two (*6*). Following fixation in 10 percent buffered osmium tetraoxide for 18 hours, the material was embedded in a mixture of 9 parts butylmethacrylate to 1 part methylmethacrylate. Without prior decalcification, sections were cut with a diamond knife and observed in the R.C.A. EMU 3-B electron microscope at 50 kv. Small uniform areas of the sections were subsequently examined by selected area electron diffraction.

At lower power (Fig. 1) a stratification of some calcified areas manifested itself as alternating, irregular bands of greater and lesser electron density. Two types of calcification fronts were observed: one was heavily mineralized and ended abruptly facing a structureless matrix of very low electron density (Fig. 2); the second type was less heavily calcified, more diffuse at its border, and faced a matrix consisting of a felt-like mat apparently containing delicate fibrillar elements (Fig. 3). It would be expected that the former type represented the older and more mature concretions, whereas in the latter the calculus was actively growing and as yet incompletely mineralized.

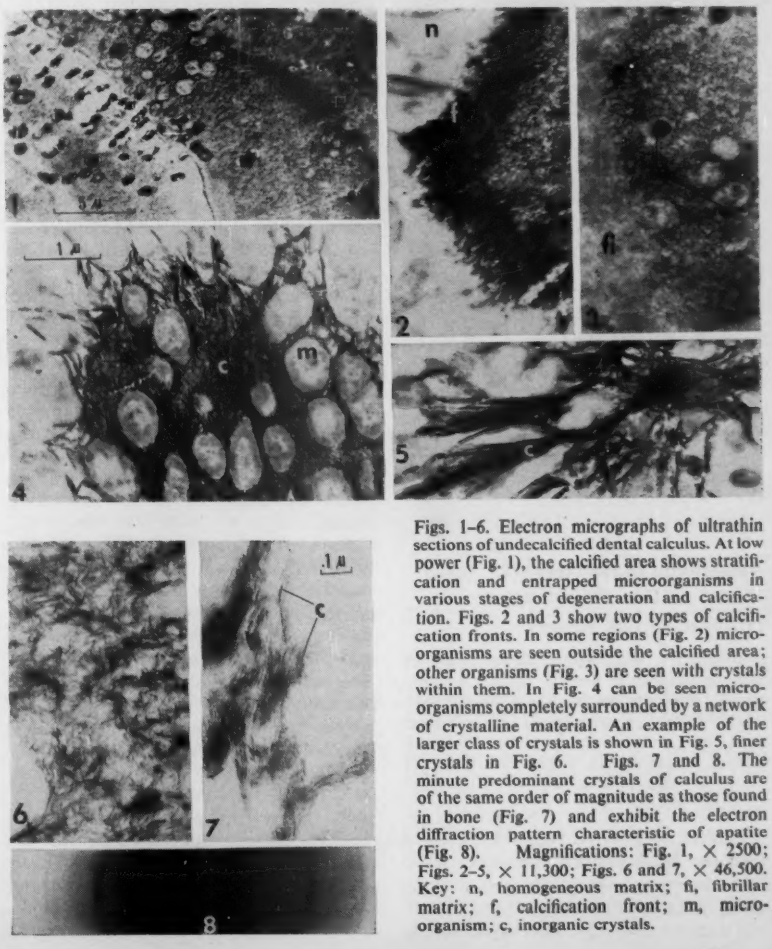
Within and beyond the areas of calcification the sectioned calculus revealed numerous circular to oblong structures, 0.4 to 0.5 μ in the smaller dimension (Fig. 4), evidently representing cross-cut microorganisms. It is known that dental calculus invariably contains a predominance of filamentous organisms, whereas other types of microorganisms, though isolated from calculus, are thought to be transients and not directly involved in calculus formation (*7*).

The organisms seen in the electronmicrographs were either completely entombed within solidly calcified bodies (Fig. 4), or outside calcified bodies within a homogeneous matrix of very low electron density (Fig. 2). Organisms found within calcified areas were in various stages of degeneration. The crystals of mineral, initially occurring in spaces between organisms (Fig. 4), eventually occurred within organisms or the spaces remaining after they degenerated (Fig. 3).

The inorganic crystals were of two principal size classes: (i) very large crystals measuring about 500 by 26,000 A (Fig. 5), and, predominantly, (ii) very fine, more or less randomly oriented crystallites measuring about 40 by 800 A, of the same order of magnitude as those in bone (compare Figs. 6 and 7).

So far we have not attempted a systematic characterization of the mineral deposits, except to indicate that the principal crystal form has the electron diffraction pattern of apatitie (Fig. 8). This direct visualization of crystals simulating typical bone salts is in keeping with chemical and x-ray diffraction studies, recently reviewed by Leung and Tovborg Jensen (*7*), according to which hydroxyapatite is always present in calculus. The admixture of other types of crystals observed in the electronmicrographs may be related to the finding that up to 60 percent of brushite ($CaHPO_4$, $2H_2O$) may be found in certain specimens of supragingival calculus from the anterior mandibular teeth (*8*), the same origin as that of calculus examined in the present study, and to the finding that 80 percent of dental calculus deposits contain whitlockite [$Ca_3(PO_4)_2$]. In these crystals the substitution with magnesium has been considered a factor which in part may inhibit the growth of the otherwise predominant apatite (*8*, *9*).

While microorganisms have been implicated in formation and attachment of calculus, it is believed that the above observations for the first time indicate that these organisms themselves may be subject to mineral deposition. In this connection, it is interesting to note that



Figs. 1–6. Electron micrographs of ultrathin sections of undecalcified dental calculus. At low power (Fig. 1), the calcified area shows stratification and entrapped microorganisms in various stages of degeneration and calcification. Figs. 2 and 3 show two types of calcification fronts. In some regions (Fig. 2) microorganisms are seen outside the calcified area; other organisms (Fig. 3) are seen with crystals within them. In Fig. 4 can be seen microorganisms completely surrounded by a network of crystalline material. An example of the larger class of crystals is shown in Fig. 5, finer crystals in Fig. 6. Figs. 7 and 8. The minute predominant crystals of calculus are of the same order of magnitude as those found in bone (Fig. 7) and exhibit the electron diffraction pattern characteristic of apatite (Fig. 8). Magnifications: Fig. 1, × 2500; Figs. 2–5, × 11,300; Figs. 6 and 7, × 46,500. Key: n, homogeneous matrix; fi, fibrillar matrix; f, calcification front; m, microorganism; c, inorganic crystals.

Pautard (*10*) has found, in *Spirostomum ambiguum*, a ciliated protozoan, intracellular deposition of apatite "bone" salts with an x-ray diffraction pattern indistinguishable from that of extracellular mesodermal hard tissue matrices.

Evidently, the "matrix" outside of the microorganisms represents the bulk of the calcified deposits; but it is not known to what extent the microorganisms contribute to the conversion of this initially amorphous substance, presumably salivary mucus, into a calcifiable framework. The nature of this matrix is basic to a fuller understanding of apatite nucleation in biological systems (*11*).

F. GONZALES*
R. F. SOGNNAES
Harvard School of Dental Medicine, Boston, Massachusetts

References and Notes

1. R. F. Sognnaes, Ed., *Calcification in Biological Systems* (American Association for the Advancement of Science, Washington, D.C., in press.)
2. R. A. Robinson, *J. Bone and Joint Surg.* **34A**, 389 (1952).
3. R. A. Robinson and M. L. Watson, *Ann. N.Y. Acad. Sci.* **60**, 596 (1955).
4. S. F. Jackson and J. T. Randall, in *Bone Structure and Metabolism* (Little, Brown, Boston, 1956), pp. 47 ff.
5. M. F. Glimcher, A. J. Hodge, F. O. Schmitt, *Proc. Natl. Acad. Sci. U.S.* **43**, 860 (1957).
6. Specimens of dental calculus were kindly provided by Dr. Paul Goldhaber.
7. S. W. Leung and A. Tovborg Jensen, *Intern. Dental J.* **8**, 613 (1958).
8. A. Tovborg Jensen and M. Danö, *J. Dental Research* **33**, 741 (1954).
9. ——— and S. L. Rowles, *Acta Odontol. Scand.* **15**, 121 (1957).
10. F. G. E. Pautard, *Biochim. et Biophys. Acta* **28**, 514 (1958); "Calcification in unicellular organisms," in *Calcification in Biological Systems* (*1*).
11. This study was aided by grants from the U.S. Public Health Service (D-662) and from the William F. Milton Fund and Higgins Trust of Harvard University.
* U.S. Public Health Service senior research fellow (SF-223) on leave from the University of Texas Dental Branch, Houston, as research associate in anatomy, Harvard School of Dental Medicine (1958–59).

8 August 1959

Application of the Network Model to Gas Diffusion in Moist Porous Media

Abstract. Millington's description of pore structure in porous media is compared with conclusions based on the network theory. Experimental gas-diffusion data for moist sand indicate that this porous material has a network structure in which each pore is connected to about 15 other pores.

Millington (*1*) has recently presented a theory from which he derives a relation between gas diffusion through moist porous media and the moisture content of the material. His theory is based on a consideration of the planar distribution of spherical pores and the interconnection of pores in two adjacent planes. Millington uses Taylor's experimental data (*2*) to establish the validity of his theory.

The purpose of this report is to point out that Taylor's experimental data can be used to support a different theoretical treatment of pore structure in porous media. This treatment, based on the network model of a porous material (*3*), gives more detailed information on pore structure than does Millington's theory.

Although Millington limits himself to a discussion of diffusion through the gas space in dry and moist porous media, the same theory and equations apply to electrical conduction through electrolyte-containing porous media (*4,5*). The following equivalences can be shown to exist because of the equivalence of Ohm's law and Fick's first law of diffusion. (i) Steady-state diffusion of gas through a dry porous medium is governed by the same type of equation as is electrical conduction through a porous medium saturated with electrolyte. (ii) Steady-state diffusion of gas through a moist porous medium is governed by the same type of equation as is electrical conduction through a porous medium which contains a nonconducting fluid (oil) as the wetting phase and an electrolyte as the nonwetting phase. A brief, but perhaps oversimplified, definition of wetting phase is that it is the fluid phase which is spread on the internal surface of the porous material; conversely, the nonwetting phase is the fluid phase which occupies only the central portion of each pore space. In moist sand or soil the nonwetting phase is air and the wetting phase is water. If the porous material is exposed to the vapors of an organosilane, its surface will become hydrophobic. Water, or an electrolyte, will then be the nonwetting phase, while gas or oil is the wetting phase.

I have previously shown (*3*) that by treating a porous medium as a network of interconnected tubes, a relation can be obtained between electrical conductance and fraction of pore space occupied by a nonwetting electrolyte. This relation was shown to be dependent on the extent of interconnection of the tubes (pores) in the network, but independent of the pore size distribution.

To facilitate comparison of Millington's theory, the network theory, and Taylor's experimental data, it was desirable to state the diffusion coefficient and the moisture content relative to the dry porous material. In Fig. 1, D_M/D_d is the effective diffusion coefficient for gas in moist porous sand divided by the effective diffusion coefficient in the same sand when dry. The air-filled-pore volume is given as a fraction of the total pore volume.

Figure 1 shows a comparison of Millington's theoretical results, Taylor's experimental data, and the results from network models in which there are ten, seven, and four pores, respectively, connected to each pore. It is apparent from Fig. 1 that the network model predicts a relation between effective diffusion coefficient and moisture content that is slightly better than the one obtained by Millington. The network model in which each pore is connected to ten others gives results that are in fair agreement with Taylor's experimental data. From the trend of the network-model results, it seems reasonable to expect that the relationship of the effective diffusion coefficient versus the moisture content from a network in which each pore is connected to about 15 other pores will be in almost perfect agreement with the experimental data.

This observation gives support to the conclusion I had reached previously (*3*) by comparing data on experimental wetting-phase electrical conductivity with predictions from the network model. From my earlier work I concluded that the characteristic shape of a plot of experimental electrical conductivity in the wetting phase versus moisture content was a result of the network structure of porous media. Furthermore, the numerical value of these experimental data, when compared to predictions from the network model, suggested that in materials such as sand there are seven to 25 pores connected to each pore. Both Taylor's

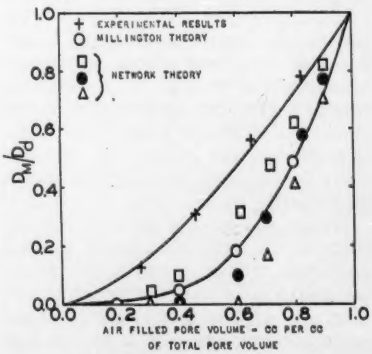


Fig. 1 Gas diffusion in a porous solid-liquid-gas system—a comparison of Taylor's experimental results (*2*), Millington's theory (*1*), and network theory (*3*). Number of pores connected to each pore in the network are: squares, 10; solid circles, 7; and triangles, 4.

experimental data and the previous experimental data on wetting-phase electrical conductivity can be interpreted in terms of the network model, and both suggest about the same degree of pore interconnection (*6*).

IRVING FATT
Department of Mineral Technology, University of California, Berkeley

References and Notes

1. R. J. Millington, *Science* **130**, 100 (1959).
2. S. A. Taylor, *Soil Sci. Soc. Am. Proc.* **14**, 55 (1949).
3. I. Fatt, *Trans. Am. Inst. Mining Met. Engrs.* **207**, 144 (1956).
4. R. K. Schofield and C. Dakshinamurti, *Discussions Faraday Soc. No. 3* (1948), p. 56.
5. M. Kimura, K. Veda, T. Ofuka, *Chem. Eng. (Tokyo)* **21**, 17 (1957); English summary in *A. I. Ch. E. Journal* **5**, 267 (1959).
6. Pore-structure studies in this laboratory have been supported by grant-in-aid No. 67 of the American Petroleum Institute.

8 August 1959

Effect of Stress on Skin Transplantation Immunity in Mice

Abstract. Chronic avoidance-learning stress was found to depress the immune reaction responsible for skin homograft rejection to a modest but significant degree. This effect was observed in a genetically uniform as well as a heterogeneous line of mice.

Although diverse types of systemic stress have long been known to modify the immunological responses of mammals (*1*), precise experimental investigations have recently elucidated the effect of such stress on particular immune reactions. Thus, mice subjected to a standardized avoidance-learning type of stress show an increased susceptibility to *Herpes simplex* virus infection (*2*) as well as a decreased susceptibility to passive anaphylaxis (*3*) and a depressed colloid-clearing capacity of the reticuloendothelial system.

The study discussed here was undertaken to determine the effect of controlled stress on skin-homograft rejection. The immunologic basis of the homograft reaction has been well established and shows the characteristics of a typical hypersensitivity of the delayed type (*4*).

The stressing procedure employed has been described in detail by Rasmussen *et al.* (*2*). The apparatus makes use of a shuttle box with wired floor each half of which is alternately electrified with a 20- to 30-volt current painful to the mouse. Alteration of current from one side to the other is preceded by signals from a light and buzzer. Mice soon learn to avoid the shocking current, which occurs at about 5-minute intervals. The animals are subjected to this stress 6 hours per day, 6 days per week. Such stress regularly engenders significant changes in the weights of organs: the weights of the thymus and spleen decrease, whereas those of the liver and adrenal increase. Moreover, a progressive leukopenia occurs as the stress is continued over several weeks. Randomly bred Swiss-Webster BRVS mice for which the stress parameters have been determined (*2*) were employed, along with highly inbred C57B1 and A-line mice. Single, orthotopic skin homografts were made by the technique of Billingham and Medawar (*5*) in two donor-recipient combinations—A→C57B1 and C57B1→Swiss. Thus, both inbred and genetically diverse recipients were tested. The Swiss recipients were all virgin females, whereas both sexes were represented in the C57B1's.

Mice about 5 weeks old were exposed to the standardized stress experience for 2 weeks before grafting. On the day after grafting, the mice were again subjected to stress until homograft rejection was complete. The control mice received grafts in the same manner but were not exposed to experimental stress. Protective bandages were removed for the initial inspection on the 8th day, and graft survival was scored daily thereafter. Intermediate stages of breakdown were estimated by gross inspection and confirmed in several instances by histologic examination of biopsy sections stained with hematoxylin and eosin. Zero survival end points were assessed on the basis of no surviving graft epithelium. Median survival times as well as tests for parallelism and reaction-time ratios, with their 95-percent confidence limits, were computed by the method of Litchfield (*6*).

The cumulative percentage of homografts destroyed in each experiment is plotted against days after grafting in Fig. 1. While it is apparent that the time-mortality distributions of grafts in the comparable groups of control mice and stressed mice are distinctive, the prolongation of skin homograft survival in the stressed mice was not extensive. Also, the figure reveals that the uniform C57B1 recipients showed a narrow range of graft-survival times, whereas the Swiss mice showed the broad distribution characteristic of genetically diverse recipients. The results are summarized in Table 1. When the data were subjected to the parallelism and reaction-time ratio tests of significance, the difference between stressed and control mice in both combinations is significant at the 95-percent level of probability.

Although the stress applied is known to induce profound physiological changes in mice, it appears probable that the observed inhibition of transplantation immunity in stressed mice is affected primarily by hypersecretion of adrenal corticosteroids. Indeed, the decrease in weight of the spleen and the progressive leukopenia in stressed mice can be duplicated by administration of cortisone. Since homograft immunity, like other delayed types of hypersensitivity, is clearly mediated by lymphoid cells, a substantial depression of such cells by corticosteroids would be expected to allow a prolongation of skin homograft survival. Nevertheless, the endocrine situation is complex. While the normal mouse secretes principally corticosterone and little if any cortisone and hydrocortisone (*7*), Medawar and Sparrow (*8*) have shown that injection of the latter compounds but not of corticosterone will prolong homograft survival time in mice. An analysis of the endogenous corticosteroid levels in stressed mice now under way in this laboratory should indicate whether such mice preferentially secrete the hormones known to prolong homograft survival. The possibility remains, of course, that the stress-induced inhibition of the homograft reaction is mediated mainly through channels other than the adrenal corticoids. In this connection, studies with rats (*9*) have revealed that adrenal corticoid output may actually decrease below normal levels during prolonged stress.

It should be noted that our control mice were unfortunately exposed to the periodic noise of building reconstruc-

Table 1. Summary of results.

Group	Donor-recipient combination	No. of mice	Median survival times (days) with 95% confidence limits
Control	A→C57B1	7	8.2 (7.2–9.3)
Stressed	A→C57B1	11	9.6 (9.3–9.9)
Control	C57B1→Swiss	23	8.5 (8.3–8.7)
Stressed	C57B1→Swiss	21	9.2 (8.6–9.9)

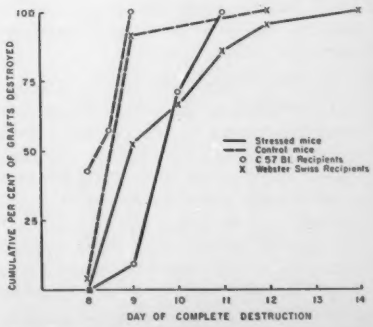


Fig. 1. Cumulative time-mortality curves for skin homografts in stressed and non-stressed mice.

tion and thus were moderately stressed. Some additional stress may also have resulted from caging the animals singly. Hence, the difference between experimental and control groups might be more striking under ideal conditions.

Even though the physiological pathways of action are still poorly defined, it is clear that chronic, avoidance-learning stress induces a prolongation of homograft survival times to a small but significant degree in genetically homogeneous as well as in heterogeneous lines of mice (*10*).

R. WISTAR, JR.*
W. H. HILDEMANN
Department of Infectious Diseases, School of Medicine, University of California, Los Angeles

References and Notes

1. H. Selye, *Science* **122**, 625 (1955).
2. A. F. Rasmussen, Jr., J. T. Marsh, N. Q. Brill, *Proc. Soc. Exptl. Biol. Med.* **96**, 183 (1957).
3. A. F. Rasmussen, Jr., E. S. Spencer, J. T. Marsh, *ibid.* **100**, 878 (1959).
4. L. Brent, J. Brown, P. B. Medawar, *Lancet* **2**, 561 (1958).
5. R. E. Billingham and P. B. Medawar, *J. Exptl. Biol.* **28**, 385 (1951).
6. J. T. Litchfield, Jr., *J. Pharmacol. Exptl. Therap.* **97**, 399 (1949).
7. F. Halberg, R. E. Peterson, R. H. Silber, *Endocrinology* **64**, 222 (1959).
8. P. B. Medawar and E. R. Sparrow, *J. Endocrinol.* **14**, 240 (1956).
9. K. M. Knigge, C. H. Penrod, W. J. Schindler, *Am. J. Physiol.* **196**, 579 (1959).
10. This work was supported by research grants (E835 and C4027) from the National Institutes of Health, U.S. Public Health Service, Bethesda, Md.
* U.S. Public Health Service post-sophomore fellow.

31 August 1959

Growth Pattern in the Green Hydra, Chlorohydra viridissima

Abstract. A method was employed whereby it was possible to determine the growth pattern of hydra without using the traditional techniques of grafting and vital staining. It has been shown that hydra possess a growth region just below the hypostome where constant cell proliferation renews the tissues of the animal completely every few weeks.

In 1949 Brien and Reniers-Decoen (*1*) published an account of the growth pattern exhibited by the common brown hydra, *Pelmatohydra oligactis* (Pallas). These investigators grafted upper portions (mouth, tentacles, hypostome, and the region just below the hypostome) of animals which had been stained vitally with methylene blue, neutral red, and Nile blue sulfate to the stalk or peduncular region of unstained animals. During the next few weeks the stained material migrated towards the basal disk, where, after a period of from 3 to 5 weeks, the stained material disappeared entirely. These workers concluded from the experiments that hydra possess a growth region just under the hypostome where rapid cell division occurs in both epidermis and gastrodermis. As cells divide they force nondividing cells proximally to the basal disk and distally to the tentacle tips, where these migrating cells die and are sloughed off. Thus, it appears that the hydra is constantly renewing its tissues every 3 to 5 weeks.

This discovery of Brien and Reniers-Decoen, if correct, will influence to a great extent future interpretations of experiments dealing with growth and cell differentiation in hydra, because it was formerly believed that the hydra's "immortality" was dependent only upon a constant tissue replacement by interstitial cells in all areas of the body.

The present study was an attempt to confirm the existence of a growth region in hydra and to determine whether a growth region exists in species of hydra other than *Pelmatohydra oligactis*. Also, it was necessary to devise a method of staining which did not involve vital dyes, since there is a possibility that these dyes are capable of diffusing from cell to cell, thus mimicking cell movement. Furthermore, it was desirable to eliminate the grafting techniques applied to experimental animals, because it appeared that these procedures were not altogther satisfactory for studying the normal growth process of an animal. In any grafting precedure applied to hydra a wound must be made in each of the pieces to be joined. Once the pieces are united, a certain amount of regeneration is necessary to repair the wounded tissue. New nervous and muscular tissue must be made, for example. It is never possible to cut sections which exactly complement each other from two different animals. In a given hydra there is a certain distance which separates the hypostome from the budding region, the distance depending upon the dominance exerted by the mouth in the immediate vicinity. This distance is further dependent upon the size and physiological state of the animal. Thus, when a proximal portion of one animal is grafted to the distal portion of another, a process of regulation must occur while the body regions of the newly formed animal are being adjusted. During this period of regeneration and regulation it is possible that cells are called to service from distant body areas to aid in repair processes and so on. Also it appeared possible that active cell proliferation might have begun at the site of the wound, thus establishing a temporary growth region.

A relatively simple procedure was found for marking the cells of the green hydra, *Chlorohydra viridissima*. Whitney (*2*) found that a green hydra when placed in a 0.5-percent glycerin solution for a few days voided its algal bodies. Several "white" animals resulting from this treatment were cut through the center of their budding zones into two pieces. The piece containing the head and tentacles was then grafted to the base, stalk, and lower half of the budding region of a normal green animal. This results in an animal whose budding region is half green and half white. The buds produced from such animals are also sometimes half green and half white, but usually the buds are white with irregular green blotches. These irregularly colored forms were then allowed to reproduce, and after several hundred of their offspring and of the offspring of succeeding generations had been examined, it was possible to find about two dozen animals with only a single patch or two of algal-laden digestive cells in their bodies. Thus, we had essentially a stained animal which was not directly involved in grafting procedures. Also, it may be assumed that no diffusion of algal cells from one cell to another in hydra will occur, since an individual algal cell is as large as the digestive cell nucleus. All that was necessary at this point was to observe the fate of algal-laden digestive cells in the growth region over a period of several days.

In 15 animals examined there was a distal and proximal migration of colored cells from the growth region. In many cases the colored material moved down only one side of the body column, showing that diffusion was not taking place. It usually took from 2 to 3 weeks for cells to be forced from the growth region to the basal disk and less than a week (average, 5 days) for cells to be forced from the growth region to the tips of the tentacles.

It may be concluded that a growth region does exist in *Chlorohydra viridissima* similar to that found in *Pelmatohydra oligactis*. Furthermore, these experiments indicate that the cell migration witnessed after staining *P. oligactis* with vital dyes was not due to regenerative and regulative processes involved in grafting procedures.

It is hoped that this simple marking procedure will be employed more in the future for the study of such processes as budding, wound healing, and reorganization of animals from bits of tissue.

ALLISON L. BURNETT
MICHAEL GAROFALO*
Department of Zoology, Cornell University, Ithaca, New York

References and Notes

1. P. Brien and M. Reniers-Decoen, *Bull. biol. France et Belg.* **82**, 293 (1949).
2. D. D. Whitney, *Biol. Bull.* **15**, 241 (1908).

* Present address: Albany Medical School, Albany, New York.

26 August 1959

Hollow Crystals from Buffer Solutions of Sodium Diethyl Barbiturate

Abstract. Buffer solutions of sodium 5,5′-diethyl barbiturate, after standing at 4° to 8°C for 7 weeks, were observed to contain large tubular crystals. The crystals appear to have the composition of 5,5′-diethyl barbituric acid. They can be grown readily from fresh seeded solutions.

Large, hollow, tubular crystals in buffer of sodium 5,5′-diethyl barbiturate were unexpectedly observed in this laboratory. Chrysotile asbestos (*1*), halloysite (*1*), pyromorphite (*2*), nitroguanidine (*3*), and vanadinite (*4*) have been previously reported as cavernous, tubular, or hollow crystals. The first two are microscopic; nitroguanidine crystals are about 2 mm long, the vanadinite ones about 10 mm. Various crystal forms of 5,5′-diethyl barbituric acid, of which none were hollow, have been described (*5*). Recently, tubular hexamethylene-tetramine-triphenol was reported (*6*). Because of their unusual form, dimensions, and pyrimidine nature, the observed crystals are described here.

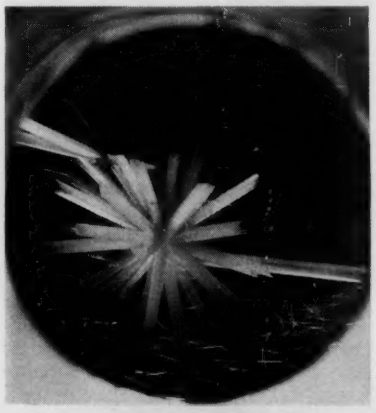


Fig. 1. Appearance of rosette of crystals in mother liquor (about × ½).

Fig. 2. A pair of tubes, unseparated; removed from rosette. Scale numbers represent centimeters.

16.0 gm of NaOH (reagent grade, Merck) and 88.4 gm of 5,5′-diethyl barbituric acid (N.F. Barbital Merck) were dissolved in water at a total volume of 4 liters. The solution was inadvertently left unstoppered at 4° to 8°C for about 7 weeks. During that period, crystal growth occurred to produce the large rosette shown in Fig. 1. The rosette consists of 30 hollow tubes, each with parallel outer edges in the long axis, all radiating from a common area at a closed end of each tube. Each tube was open at the other end and was about 30 to 40 mm long. The tubes could be broken away in smaller clusters, in pairs (Fig. 2), or as single crystals. Each central end was pointed and solid, not hollow. The two crystals shown in Fig. 2 formed an angle of 17 ± 0.5 deg with each other. The open shaft in one crystal (Fig. 2) was found to end 3 mm from the pointed, closed tip, and in all crystals the open shaft extended to a similar distance from the tip. The tubes were 2 to 4 mm in outside diameter, colorless, moderately translucent, brittle, and smooth to the touch. The outer edges of four crystals, measured in photographs, were found to be parallel (± 0.2 mm over a length of 20 mm).

For analysis, crystals were removed from the rosettes while in the mother liquor by means of a slight wedging motion of a spatula. After the fluid contents from the interior of each had been aspirated with a fine capillary, and the crystals had been washed inside and out quickly with cold water, the separated tubes were dried in a desiccator at 12 mm-Hg over P_2O_5 for 18 hours. After being dried they were sectioned transversely with a razor blade; some fracturing occurred. The open ends could be gently ground until somewhat flat. The interior and contours of the walls were somewhat hexagonal (see Fig. 3).

Analysis showed mp 181° to 184°C (uncorrected) with simultaneously measured mp on acid barbital (N.F., Merck) of 184.5°C and mixed mp 184.5°C, [reported 176°, 183°, and 190°C for various crystal forms (*5*)]. Sodium barbital (USP, Merck) decomposed well over 200°C. Sodium content (flame, Beckman) of supernatant removed from a solution of the dried crystals that had been allowed to recrystallize (needles) overnight at room temperature showed a value of 0.3 percent of that expected for a saturated solution of sodium barbital at 25°C. This supernatant had a *p*H of 5.7 ± 0.05 and after evaporation was found to contain 0.77 ± 0.05 gm of solute per 100 ml (solubility of 5,5′-diethyl barbituric acid = 0.69 gm/100 ml at 25°C; of sodium 5,5′-diethyl barbiturate = 20.0 gm/100 ml at 25°C). It is quite possible, therefore, that the hollow crystals are simply monomeric 5,5′-diethyl barbituric acid.

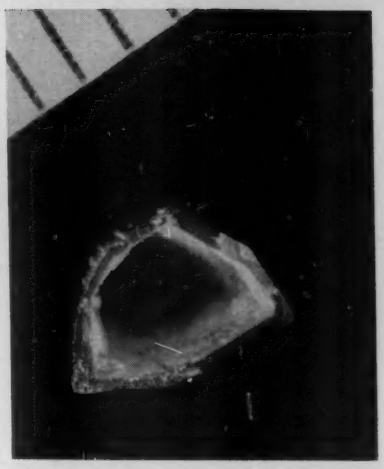


Fig. 3. Cross section of hollow crystal near open end. One scale division equals 1 mm.

Crystals were grown once before in a similar buffer solution at *p*H 8.6 ± 0.05. Also, four times they have been grown in a matter of days by seeding with very small crystal fragments (*7*).

W. F. Seip

F. W. Barnes, Jr.

Departments of Medicine and *Physiological Chemistry, Johns Hopkins Medical Institutions, Baltimore, Maryland* and *Department of Medicine, Hospital for the Women of Maryland, Baltimore, Maryland*

References and Notes

1. T. E. Bates, L. B. Sand, J. F. Mink, *Science* **111**, 512 (1950).
2. G. L. English, *Getting Acquainted with Crystals* (McGraw-Hill, New York, 1934), Fig. 88.
3. J. Cohen, R. A. Henry, S. Skolnik, *Science* **111**, 278 (1950).
4. R. D. George, *Minerals and Rocks* (Appleton-Century, New York, 1943), p. 93.
5. A. Kofler, *Chem. Abstr.* **41**, 3584 (1947); Fischer, Dilthey, *Ann. Chem. Liebigs* **335**, 338 (1904).
6. P. Hamard, *Acta Cryst.* **7**, 609 (1954).

7. This information was presented at the meeting of the American Society of Biological Chemists, Atlantic City, April 1959. This investigation was supported by the Milton M. Frank Foundation, the Noxzema Corporation, and the Walter H. Hick Fund.

6 July 1959

Feeding Behavior and Electrical Stimulation of the Brain of Carassius auratus

Abstract. Bipolar electrodes were implanted in large goldfish in olfactory and nonolfactory areas of the central nervous system. Stimulation of olfactory areas elicited stereotyped feeding activity indistinguishable from normally induced behavior. It is suggested that the olfactory rather than the peripheral gustatory system plays the predominant role in the arousal of feeding activity.

In the investigations under discussion it has been possible to observe the behavior of goldfish after electrical stimulation to various areas of the brain. The study emphasized investigation of normal feeding patterns and comparison with feeding behavior in fish with implanted electrodes living in the same environment. The first part of the study dealt with the observation and description of normal behavior. Ethologists such as Lorenz (*1*) have correctly pointed out that before a casual role can be assigned to a particular act, the complete range and variation of behavior seen in the species must be known. The goldfish used in this study were 15 cm or more long. Goldfish of smaller size exhibit additional patterns of feeding but are not discussed here. The endogenous feeding maneuvers seen in the larger fish were used as a reference, and changes in this behavior during and after brain stimulation were studied.

Large goldfish feed in a characteristic way. The entire pattern, from an appetitive phase of arousal and search to the consummatory conclusion of swallowing materials, can be described in both laboratory and free-living forms. Under laboratory conditions of food deprivation, hungry fish, when encountering a familiar food odor (*2*), will demonstrate a complete feeding pattern—for example, immediate arousal and wandering, followed by a phase in which objects on the aquarium floor are selectively attacked. A non-object-seeking phase continues, with the fish canting head-to-sand, indiscriminately sampling large areas of sand for food. This activity generally signals the end of a feeding performance.

Goldfish possess an external system of taste buds, variously extending over the snout and anterior structures of the body (*3*). Since a food odor placed in the aquarium was capable of eliciting feeding behavior in the hungry fish, the experiment described below was carried out to ascertain whether the peripheral gustatory or the olfactory system played the major role in initiating feeding activity.

Two goldfish were reinforced to perform endogenous feeding patterns in the presence of a food odor. At the end of the training period, both fish, within a few seconds of encountering the odor, would exhibit typical arousal with bottom-feeding maneuvers. They exhibited this activity with absolute regularity, in isolation or together. The anterior portal of the olfactory pits of one fish was gently occluded with cotton pledgets. This temporarily prevented access of odor to the pit organ; the peripheral-skin taste system remained undisturbed. When the odor test was repeated, the control fish responded with a feeding performance; the other fish showed no response. This experiment could be repeated, either fish serving as control. From these observations, it was concluded that an olfactory cue triggered feeding activity in hungry fish.

A second phase in the study of feeding behavior involved chronic implantation of bipolar electrodes in olfactory and nonolfactory areas of the brain. Stimulation of the olfactory crura, extending from olfactory bulb to forebrain, initiated the complete feeding performance described for control fish, and this corroborated the observations on olfactory occlusion.

Table 1 summarizes data from investigations on 15 fish with electrode implantations. The average number of sessions for each fish in the experimental situation was four. Each session, which included several experiments at different implantation sites, lasted between 2 and 4 hours. Feeding performance was evaluated in terms of intensity and completeness of response. Intensity was a measure of the motor components characterizing the response; completeness was measured by comparison with control fish under conditions of food deprivation.

Stimulation of olfactory crura produced complete feeding responses in nine of 13 fish, with the arousal, intention movements, and low-intensity feeding commonly seen in other experiments. The stimulus parameters were 0.075- to 0.15-ma pulses of 0.5-msec duration, in pulse trains of 10 to 25 seconds at regular intervals of 1 to 3 minutes. Frequencies of 30 to 50 pulses per second gave the best feeding responses. Higher frequencies were ineffective. Adrian and Ludwig (*4*), using decapitated specimens of carp and goldfish, reported normal discharges of 40 per second from the olfactory bulb after the flushing of odoriferous food materials across the olfactory organ. This agrees with our data on the frequency of stimulus used in central arousal of feeding in goldfish.

The forebrain areas stimulated encompassed the lateral and medial olfactory regions of secondary synapse and the anterior aspects of piriform and hippocampal elements. In only one of 15 implants was a complete and intense pattern seen after forebrain stimulation. Generally, when forebrain responses occurred, they were often preceded by experiments in which crural feeding responses were seen. Responses from this area were characteristically incomplete and of low intensity, coming in single rather than continuous displays. Lower current ranges of 20 to 60 μa were effective.

Stimulation of vagal lobes produced no preliminary feeding arousal. Feeding maneuvers observed in response to stimulation were also preceded by successful crural responses. The movements were sudden and incomplete, and came as solitary events during the course of an experiment. Stimulus parameters were similar to those in forebrain studies. Other areas stimulated showed no feeding responses (*5*).

Table 1. Data on electrical stimulation of the brain and on feeding behavior in *Carassius auratus*.

Area of stimulation	Fish	No. of expts.	Nonfeeding motor responses	Feeding		Complete feeding performance	
				Arousal	Intention movements	Low intensity	High intensity
Crura	13	44	13	12	7	1	11
Forebrain	15	50	26	4	6 (4)*	11 (6)*	3†
Vagal lobe	5	10	2	0	4 (3)*	4 (3)*	0
Facial lobe	4	6	6	0	0	0	0
Valvula	5	9	9	0	0	0	0
Cerebellum	2	3	3	0	0	0	0

* Stimulation of olfactory crura preceded this experiment by several minutes or more. Numbers in parentheses represent successful crural feeding responses. † Data recorded from the same fish.

ROBERT J. GRIMM
Department of Physiology, University of Michigan, Ann Arbor

References and Notes

1. K. Lorenz, *Symposia Soc. Exptl. Biol. No. 4* (1950), p. 221.
2. The food odor was that of a rodent pellet extract (Staley's Rockland rabbit ration).
3. C. J. Herrick, *J. Comp. Neurol.* **15**, 375 (1905).
4. E. D. Adrian and C. Ludwig, *J. Physiol. (London)* **94**, 441 (1938).

5. This report is adapted from a thesis submitted in partial fulfillment of the requirements for an M.S. degree in physiology. This work was supported by a U.S. Public Health Service postsophomore medical school fellowship (PX-117-3) and by grants to R. W. Doty from the Foundation Fund for Research in Psychiatry and from the National Institute of Neurological Diseases and Blindness (B-1068).

8 September 1959

Inhibition of Central Auditory Response

Abstract. Suitable electrical stimulation of the region of the decussation of the olivocochlear bundles, which supply efferent innervation to the organ of Corti, was found to abolish the response of the auditory cortex to a click, without changing the responses (N_1 and N_2) of the eighth nerve in cats. At higher stimulation values the eighth nerve responses also were abolished, and at intermediate stimulus values responses at the medial geniculate and inferior colliculus were suppressed.

Inhibitory pathways of the nervous system have been much studied in recent years. In the auditory field, Rasmussen (*1*) found efferent fibers (the olivocochlear bundle) to the peripheral organ, and Galambos (*2*) reported that under certain conditions stimulation of these efferent fibers markedly reduces the N_1 and N_2 components of the changes in electrical potential that occur at the round window membrane when the ear is exposed to sound. Desmedt (*3*) located, in the posterior lateral part of the diencephalon, an area the stimulation of which decreased the potentials evoked in the cochlear nuclei. The experiments that are reported here demonstrate a further effect of stimulating the region of the olivocochlear bundle.

Thirty-four adult cats were anesthetized with Nembutal (25 mg/kg) and maintained at a light level of sedation. One animal, in addition to Nembutal, after the insertion of an endotracheal tube, was given a constant infusion of a neuromuscular blocking agent, Flaxidle, and maintained on artificial respiration. The level of the Flaxidle was such that no movement could be elicited by any means of stimulation. Potentials were recorded from the auditory cortex with a monopolar silver ball electrode, from the medial geniculate and inferior colliculus with bipolar stainless steel electrodes, and from the round window with a silver foil electrode. A stainless steel bipolar electrode with an outside diameter of not more than 2 mm was used to stimulate the region of the olivocochlear bundle. A pair of Tektronix type 122 preamplifiers and cathode ray oscilloscope were used to amplify the responses. Auditory stimuli consisted of a 0.075-msec click delivered by a crystal microphone connected to a hollow ear bar. Electrical shocks to the region of the olivocochlear bundle were generated by a Grass stimulator through a stimulus isolation unit. They were of 1 msec duration, at a repetition rate of 100/sec, and were on for a total duration of 320 msec. In all of the experiments there was a 5-msec delay between the end of the electrical stimulation and the onset of the click. At the end of each experiment the animal was sacrificed with all of the electrodes in place, and perfused with normal saline and then with 10-percent neutral formalin. All of the brains were saved for histologic examination.

A small region, 10 mm rostral from the obex on the floor of the fourth ventricle, was found which, upon stimulation, would inhibit the eighth nerve response, the N_1 and N_2 of the round window response. This confirmed the previous work of Galambos (*2*). When stimuli to the region of the olivocochlear bundle which were not strong enough to inhibit the N_1 and N_2 were used, the cortical-evoked potential to a click was markedly suppressed or abolished (Fig. 1). Cortical suppression was accompanied in some animals by a slight reduction in the eighth nerve response and in others by no change at all in the eighth nerve response. These observations have been repeated in 34 animals. The response at the medial geniculate to a click was suppressed by shocks to the region of the olivocochlear bundle. These shocks were also accompanied by some reduction but not total suppression of the eighth nerve response. The same relationship was found for the inferior colliculus, in that it could be suppressed, but only after the N_1 and N_2 were somewhat diminished. The inferior colliculus in some animals was never totally suppressed until the eighth nerve response was abolished.

In all of the experiments the region which gave the maximal central inhibition was identical with that which gave the maximal suppression of the eighth nerve response. Stimulation of the olivocochlear region did not suppress a response in the somatic cortex to single shock of a cutaneous nerve. The neuromuscular blocking agent was found to have no effect upon the suppression.

The question arises as to whether or not some structure other than the olivocochlear bundle is also being stimulated. If the central suppression is due to the olivocochlear bundle, the possibilities are that it may have other central connections, that there may be an antidromic effect, or that there may be certain key fibers in the eighth nerve essential for a cortical-evoked potential which are being selectively inhibited (*4*).

ROBERT J. RUBEN
JAN SEKULA*
Department of Otolaryngology, Johns Hopkins University School of Medicine, Baltimore, Maryland

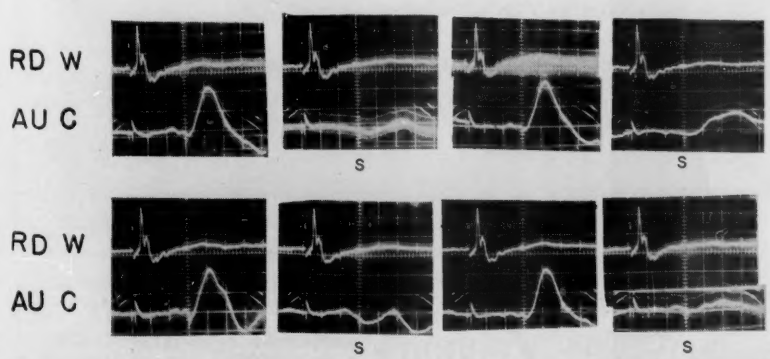


Fig. 1. Cat No. 62. Eight consecutive responses at the round window (*RD W*) and the auditory cortex (*AU C*) to a click. *S* indicates that the region of the olivocochlear bundle was stimulated with a series of shocks at 4 volts in the manner described in the text, before the click was presented. Note the suppression of the cortical response without any change in the round window response. One large division vertically is 5 μv and horizontally is 5 msec.

References and Notes

1. G. L. Rasmussen, *J. Comp. Neurol.* **84**, 141 (1946).
2. R. Galambos, *J. Neurophysiol.* **19**, 424 (1956).
3. J. E. Desmedt and K. Mechelse, *Proc. Soc. Expil. Biol. Med.* **90**, 772 (1959).
4. This work has been supported by grants from the Alfred P. Sloan Foundation and the National Institute of Neurological Diseases and Blindness.
* Fellow of the Rockefeller Foundation. Permanent address: Medical Academy, Cracow, Poland.

8 August 1959

Meetings

Calorimetry

Over 100 calorimetrists from the United States, Canada, and Europe gathered in Yale University's Sterling Chemistry Laboratory from 10 to 12 September for the 14th annual Calorimetry Conference. Under the chairmanship of David White (Ohio State University) they heard and discussed 30 technical papers covering nearly all phases of calorimetry—heat capacity measurements at temperatures as low as 0.1°K and as high as 1400°K, precision reaction and bomb calorimetry, solution calorimetry, and determinations of stored energy in solids.

Most of the papers were concerned with topics not even mentioned at early calorimetry conferences, and many reported on developments of the past few months. Nevertheless, as calorimetric techniques are extended to more extreme conditions, the problems that led to the founding of the conference remain, under new guises. The need for better temperature-measuring devices—the first item on the agenda of the 1st Calorimetry Conference—was emphasized again in seven papers that reported on research at temperatures below 11°K. No device comparable to the platinum resistance thermometer now in general use for measurements above 11°K is yet available for the very low temperatures at which some of the most important calorimetric research is now being done. However, the conference heard enthusiastic reports on a device that may extend precision thermometry to at least 1°K—the germanium resistance thermometer developed at Bell Telephone Laboratories. Bell furnished 12 of these thermometers for a Calorimetry Conference test program involving 11 different laboratories. Three papers at the Yale conference described the first results of this program, which are so promising that the conference plans to seek a manufacturer of additional units for a more extensive testing program.

Feature addresses were given by George S. Parks (Stanford University) and Lars Onsager (Yale University). At the annual banquet, Parks delivered the Hugh M. Huffman Memorial Lecture, "Some Remarks on the Thermodynamic Properties of Organic Compounds." Parks and one of his first graduate students, the late Dr. Huffman, started the first systematic calorimetric studies of organic compounds at Stanford over 30 years ago. Parks traced the history of thermodynamic research on organic substances and the role that improvement of calorimetric methods has played in the remarkable progress made in the last three decades.

Onsager gave the principal lecture of the technical sessions, on "Cooperative Phenomena," a field in which he has developed much of the basic theory. Many papers at each calorimetry conference describe experimental studies of cooperative phenomena, and Onsager outlined the approaches one may take in seeking a theoretical understanding of such effects. Admitting that three-dimensional treatments of critical phenomena by statistical mechanics seem hopelessly complex, he dwelt mostly on more simplified treatments that give results.

In addition to the objective of promoting better calorimetric research, the conference also is concerned with publication policies relating to calorimetric and thermodynamic articles. A "resolution regarding published calorimetric data" adopted by the 8th conference, in 1953, has proved to be valuable to editors and authors alike in establishing consistent policies based on the opinions of experts in the field. Because calorimetric research has expanded into many areas not covered by the 1953 resolution, the 14th conference established a committee headed

by J. P. McCullough to consider revising and extending the earlier recommendations.

Edgar F. Westrum, Jr. (University of Michigan) and Stig Sunner (University of Lund, Sweden) presented a proposal of the IUPAC Commission on Thermodynamics for a joint meeting in 1961 of the Calorimetry Conference and the subcommissions on Experimental Thermochemistry and Experimental Thermodynamics. The conference unanimously approved the proposal for a joint meeting to be held either before or after the biennial IUPAC meeting that year in Montreal, Canada. Plans will begin immediately for what should be one of the most important international conferences ever held in the field of calorimetry.

At the annual election, the following members were named to conference offices: chairman, J. P. McCullough (Petroleum Thermodynamics Laboratory, Bureau of Mines); chairman-elect, D. W. Osborne (Argonne National Laboratory); directors, 1959 to 1962, N. E. Phillips (University of California, Berkeley) and J. M. Sturtevant (Yale University). Other officers are C. E. Messer (Tufts University), secretary-treasurer, and David White, D. H. Andrews (Johns Hopkins University), J. E. Kunzler (Bell Telephone Laboratories), and J. A. Morrison (National Research Council, Ottawa), directors.

JOHN P. MCCULLOUGH
Bartlesville, Oklahoma

Forthcoming Events

February

10–11. Gas Cooled Reactor, symp., Philadelphia, Pa. (F. L. Jackson, Franklin Inst., Philadelphia, Pa.)

10–12. American Acad. of Occupational Medicine, Williamsburg, Va. (L. B. Shone, Bureau of Medicine and Surgery, Navy Dept., Washington 25.)

10–12. Solid States Circuit Conf., Philadelphia, Pa. (T. R. Finch, Bell Telephone Laboratories, Murray Hill, N.J.)

10–13. National Assoc. for Research in Science Teaching, 33rd annual, Chicago, Ill. (C. M. Pruitt, Univ. of Tampa, Tampa, Fla.)

10–13. National Soc. of College Teachers of Education, Chicago, Ill. (E. J. Clark, Indiana State Teachers College, Terre Haute.)

11. Protein and Amino Acid Requirements of Swine, Chicago, Ill. (J. T. Sime, Assoc. of Vitamin Chemists, Evaporated Milk Assoc., 228 N. La Salle St., Chicago 1.)

11–13. Society of Univ. Surgeons, Minneapolis, Minn. (B. Eiseman, 4200 E. Ninth Ave., Denver 20, Colo.)

14–18. American Inst. of Mining, Metallurgical and Petroleum Engineers, annual, New York, N.Y. (E. O. Kirkendall, AIME, 29 W. 39th St., New York 18.)

16. Astronomical Soc. of the Pacific annual, San Francisco, Calif. (S. Einarsson, Leuschner Observatory, Univ. of California, Berkeley 4.)

18–19. Chemical Inst. of Canada (Protective Coatings Div.), Toronto, Ont., and Montreal, Que., Canada. (Scientific Liaison Office, National Research Council, Sussex Drive, Ottawa, Canada.)

18–20. National Soc. of Professional Engineers, winter, Wichita, Kan. (P. H. Robbins, NSPE, 309 Bancroft Bldg., Univ. of Nebraska, Lincoln.)

21–24. American Inst. of Chemical Engineers, Atlanta, Ga. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

22–25. Technical Assoc. of the Pulp and Paper Industry, annual, New York, N.Y. (J. Winchester, TAPPI, 155 E. 44 St., New York 17.)

22–4. Scientific Management, 12th intern. cong., Sydney and Melbourne, Australia. (C. M. Gray, Federal Council of the Australian Inst. of Management, Western House, 83 William St., Melbourne, C.1, Victoria, Australia.)

24–26. Biophysical Soc., 4th annual, Philadelphia, Pa. (O. H. Schmitt, Biophysical Soc., Chairman, Program Committee, Univ. of Minnesota, Minneapolis.)

25–27. American Orthopsychiatric Assoc., Chicago, Ill. (Miss M. F. Langer, 1790 Broadway, New York 19.)

25–27. Cell Physiology of Neoplasia (14th annual symp. on fundamental cancer research), Houston, Tex. (Editorial Office, Univ. of Texas M. D. Anderson Hospital, Texas Medical Center, Houston 25.)

26. Highway Geology, 11th annual symp., Tallahassee, Fla. (W. F. Tanner, Geology Dept., Florida State Univ., Tallahassee.)

28–5. American College of Allergists, Miami Beach, Fla. (E. Bauers, 2160 Rand Tower, Minneapolis 2, Minn.)

29–3. American College of Surgeons, Boston, Mass. (H. P. Saunders, 40 E. Erie St., Chicago, Ill.)

29–4. Pittsburgh Conf. on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa. (L. P. Melnich, U.S. Steel Corp., Monroeville, Pa.)

March

3–5. American Acad. of Forensic Sciences, Chicago, Ill. (W. J. R. Camp, AAFS, 1853 W. Polk St., Chicago 12.)

4–6. National Wildlife Federation, Dallas, Tex. (C. H. Callison, 232 Carroll St., NW, Washington 12.)

6–13. American Otorhinologic Soc. for Plastic Surgery, Miami Beach, Fla. (J. G. Gilbert, 75 Barberry Lane, Roslyn Heights, N.Y.)

7–9. Wildlife Management Inst., Dallas, Tex. (C. R. Gutermuth, 709 Wire Bldg., Washington 5.)

7–11. American Soc. of Civil Engineers, New Orleans, La. (E. S. Kirkpatrick, ASCE, 33 W. 39 St., New York 18.)

10. Recent Developments in Poultry Nutrition (Assoc. of Vitamin Chemists), Chicago, Ill. (J. T. Sime, Director of Research, Evaporated Milk Assoc., 228 N. La Salle St., Chicago 1.)

13–14. American Otological Soc., Miami Beach, Fla. (L. R. Boies, University Hospital, Minneapolis 14.)

14–16. American Railway Engineering Assoc., annual conv., Chicago, Ill. (N. D. Howard, AREA, 59 E. Van Buren St., Chicago 5.)

14–17. Positive Health of Older People, forum, Miami Beach, Fla. (A. Mallach, National Health Council, 1790 Broadway, New York 19.)

15–16. American Broncho-Esophangological Assoc., Miami Beach, Fla. (F. J. Putney, 1712 Locust St., Philadelphia 3.)

15–21. Nondestructive Testing, 3rd intern. conf., Tokyo and Osaka, Japan. (S. Ishizaka, Scientific Attaché, Embassy of Japan, 2514 Massachusetts Ave., NW, Washington 8.)

17. Congress for Pharmacists, 2nd annual, Jamaica, N.Y. (Congress for Pharmacists, Public Relations Office, St. John's Univ., Jamaica 32.)

17–19. American Radium Soc., conf., San Juan, Puerto Rico. (ARS, 635 East Union, Pasadena, Calif.)

17–19. Blood Platelets, intern. symp. (by invitation only), Detroit, Mich. (Miss S. A. Johnson, Henry Ford Hospital, Detroit 2.)

17–20. International Assoc. for Dental Research, Chicago, Ill. (D. Y. Burrill, Northwestern Univ. Dental School, 311 E. Chicago Ave., Chicago 11.)

18–19. American Laryngological Assoc., Miami Beach, Fla. (L. Richards, Massachusetts Inst. of Technology, Cambridge 39.)

20–23. American Assoc. of Dental Schools, Chicago, Ill. (R. Sullen, 840 N. Lake Shore Drive, Chicago 11.)

20–26. American Cong. on Surveying and Mapping, Washington, D.C. (C. E. Palmer, American Soc. of Photogrammetry, 1515 Massachusetts Ave., NW, Washington 5.)

20–26. American Soc. of Photogrammetry, Washington, D.C. (C. E. Palmer, ASP, 1515 Massachusetts Ave., NW, Washington 5.)

21–24. American Acad. of General Practice, 12th annual, Philadelphia, Pa. (AAGP, Volker Blvd. at Brookside, Kansas City 12, Mo.)

21–24. Institute of Radio Engineers, natl. conv., New York, N.Y. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

23–25. Optical Spectrometric Measurements of High Temperatures, symp., Chicago, Ill. (F. Brech, Laboratories for Applied Science, Univ. of Chicago, 6220 S. Drexel Ave., Chicago 37.)

24–25. Human Factors in Electronics, 1st annual symp. (IRE), New York, N.Y. (J. E. Karlin, Bell Telephone Laboratories, Murray Hill, N.J.)

24–26. American Assoc. for the History of Medicine, Charleston, S.C. (J. B. Blake, c/o Smithsonian Institution, Washington 25.)

24–26. Aviation Education, 4th natl. conf., Denver, Colo. (W. Kinkley, Superintendent of Schools, Aurora, Colo.)

26–27. American Psychosomatic Soc., 17th annual, Montreal, Canada. (E. D. Wittkower, APS, 265 Nassau Rd., Roosevelt, N.Y.)

28–31. Exploitation of Natural Animal Populations, symp., Durham, England. (E. D. Le Cren, British Ecological Soc., The Ferry House, Ambleside, Westmorland, England.)

29–31. American Power Conf., 22nd annual, Chicago, Ill. (R. A. Budenholzer, Mechanical Engineering Dept., Illinois Inst. of Technology, 3300 Federal St., Chicago 16.)

29–2. National Science Teachers Assoc., 8th annual conv., Kansas City, Mo. (Miss M. R. Broom, NSTA, National Education Assoc., 1201 16 St., NW, Washington 4.)

30–31. Adrenergic Mechanisms, Ciba Foundation symp. (by invitation only), London, England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1, England.)

31–1. Continuous Culture of Microorganisms, symp., London, England. (R. Elsworth, c/o Ministry of Supply, Microbiological Research Establishment, Porton, Salisbury, Wilts., England.)

31–2. American Gastroenterological Assoc., New Orleans, La. (W. Volwiler, Dept. of Medicine, Univ. of Washington, Seattle.)

April

1–3. American Soc. of Internal Medicine, San Francisco, Calif. (R. L. Richards, 350 Post St., San Francisco 8.)

1–3. American Soc. for the Study of Sterility, Cincinnati, Ohio. (H. H. Thomas, 920 S. 19 St., Birmingham 5, Ala.)

1–4. Bahamas Medical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

2. Paleontological Research Institution, Ithaca, N.Y. (Miss R. S. Harris, 126 Kelvin Pl., Ithaca.)

2–6. American College of Obstetrics and Gynecologists, Cincinnati, Ohio. (D. F. Richardson, 79 W. Monroe St., Chicago 3.)

3–6. American Surgical Assoc., White Sulphur Springs, W. Va. (W. A. Altemeier, Cincinnati General Hospital, Cincinnati, Ohio.)

3–7. International Anesthesia Research Soc., Washington, D.C. (A. W. Friend, E. 107 St. and Park Lane, Cleveland 6, Ohio.)

3–8. Nuclear Cong., New York, N.Y. (P. Lange, Engineers Joint Council, 29 W. 39 St., New York.)

4–6. American Inst. of Electrical Engineers, Houston, Tex. (N. S. Hibsham, AIEE, 145 N. High St., Columbus 15, Ohio.)

4–6. American Inst. of Mining, Metallurgical and Petroleum Engineers (43rd Natl. Open Hearth Steel Conf. and Blast Furnace, Coke Oven and Raw Materials Conf.), Chicago, Ill. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

4–6. American Oil Chemists' Soc., Dallas, Tex. (Mrs. L. R. Hawkins, AOCS, 35 E. Wacker Drive, Chicago 1, Ill.)

4–7. Atomic Exposition, New York, N.Y. (Atomic Exposition, 117 S. 17 St., Philadelphia, Pa.)

4–8. American Soc. of Mechanical Engineers, New York, N.Y. (D. B. MacDougall, ASME, 29 W. 39 St., New York.)

4–9. American College of Physicians, San Francisco, Calif. (E. R. Loveland, 4200 Pine St., Philadelphia 4.)

5–7. Instrument Soc. of America (Natl. Chemical and Petroleum Symp.), Rochester, N.Y. (H. S. Kindler, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

5–7. Naval Structural Mechanics, 2nd symp., Providence, R.I. (E. H. Lee, Brown Univ., Providence.)

5–14. American Chemical Soc., natl., Cleveland, Ohio. (A. T. Winstead, ACS, 1155 16 St., NW, Washington 6.)

6–8. Biochemistry and Pharmacology of Compounds Derived from Marine Organisms, symp., New York, N.Y. (R. F. Nigrelli, Dept. of Marine Biochemistry and Ecology, New York Aquarium, Seaside Park, Eighth St. and Surf Ave., Brooklyn 24, N.Y.)

6–8. Hyper-Environments—Space Frontier (Inst. of Environmental Scientists), Los Angeles, Calif. (M. S. Christensen, IES, 6251 Marita St., Long Beach 15, Calif.)

6–8. Radiofrequency Spectroscopy Group, Nottingham, England. (J. E. Ingram, RSG, c/o Dept. of Electronics, Telecommunications and Radio Engineering, Univ. of Southampton, England.)

6–9. Mineral Processing, intern. cong., London, England. (B. W. Kerrigan, Institution of Mining and Metallurgy, 44 Portland Pl., London, W.1, England.)

7–8. Cathode Protection, European symp., Frankfurt am Main, Germany. (Secrétariat du Symposium, Deutsche Gesellschaft fur Metallkunde, Alteburgerstrasse 402, Koln-Marienburg, Germany.)

7–9. American Assoc. of Railway Surgeons, Chicago, Ill. (C. C. Guy, 5800 Stoney Island Ave., Chicago 37.)

7–9. Association of Surgeons of Great Britain and Ireland, Birmingham, England. (F. A. R. Stammers, 47 Lincolns Inn Fields, London, W.C.2, England.)

7–9. Optical Soc. of America, Washington, D.C. (K. S. Gibson, OSA, Natl. Bureau of Standards, Washington 25.)

8–9. American Assoc. of University Professors, Detroit, Mich. (P. R. David, Univ. of Oklahoma, Norman.)

8–9. Southern Soc. for Philosophy and Psychology, Biloxi, Miss. (E. Henderson, Dept. of Philosophy, Florida State Univ., Tallahassee.)

8–11. American Dermatological Assoc., Boca Raton, Fla. (W. M. Sams, 308 Ingraham Bldg., Miami 32, Fla.)

9–10. Histochemical Soc., 11th annual, New York, N.Y. (H. W. Deane, Albert Einstein College of Medicine, Bronx 61, N.Y.)

11–13. American College of Surgeons, Minneapolis, Minn. (H. P. Saunders, 40 E. Erie St., Chicago 11, Ill.)

11–14. American College Personnel Assoc., Philadelphia, Pa. (M. D. Hardee, Florida State Univ., Tallahassee.)

11–15. American Assoc. of Immunologists, Chicago, Ill. (C. Howe, Columbia Univ., College of Physicians and Surgeons, New York 22.)

11–15. American Inst. of Nutrition, Chicago, Ill. (G. M. Briggs, Div. of General Medical Sciences, National Institutes of Health, Bethesda, Md.)

11–15. American Physiological Soc., Chicago, Ill. (R. G. Daggs, 9650 Wisconsin Ave., NW, Washington 14.)

11–15. American Soc. for Experimental Pathology, Chicago, Ill. (F. J. A. McManus, Univ. of Alabama Medical Center, Birmingham.)

11–15. American Soc. for Pharmacology and Experimental Therapeutics, Chicago,

Ill. (K. H. Beyer, Merck Sharp & Dohme Research Laboratories, West Point, Pa.)

11–15. Federation of American Socs. for Experimental Biology, Chicago, Ill. (M. O. Lee, 9650 Wisconsin Ave., NW, Washington 14.)

11–16. American Assoc. of Anatomists, New York, N.Y. (L. B. Flexner, Dept. of Anatomy, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

11–16. American Soc. of Biological Chemists, Chicago, Ill. (F. W. Putnam, Dept. of Biochemistry, Univ. of Florida, Gainesville.)

11–16. Anatomical Congress, 7th intern., New York, N.Y. (D. W. Fawcett, Dept. of Anatomy, Harvard Medical School, Boston 15, Mass.)

11–16. Congress of Anatomy, 7th intern., New York, N.Y. (J. C. Hinsey, New York Hospital, Cornell Medical Center, 525 E. 68 St., New York 21.)

11–16. International Anatomical Cong., New York, N.Y. (D. W. Fawcett, Dept. of Anatomy, Cornell Univ. Medical College, 1300 York Ave., New York 21.)

13–15. American Public Health Assoc. (Southern Branch), Memphis, Tenn. (L. M. Groves, Shelby County Health Dept., Memphis.)

15–16. Eastern Psychological Assoc., Atlantic City, N.J. (C. H. Rush, Standard Oil Co. (N.J.), Rockefeller Plaza, New York, N.Y.)

18–21. American Astronomical Soc., Pittsburgh, Pa. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

18–22. Association of American Geographers, Dallas, Tex. (A. C. Gerlach, Map Div., Library of Congress, Washington 25.)

18–22. European Soc. of Opthalmology, 1st cong., Athens, Greece. (P. Velissaropoulis, c/o Opthalmology Clinic, Faculty of Medicine, 26, rue de l'Université, Athens, Greece.)

19–21. Active Networks and Feedback Systems, 10th intern. symp., New York, N.Y. (H. J. Carlin, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

19–21. American Soc. of Lubrication Engineers, annual, Cincinnati, Ohio. (C. L. Willey, ASLE, 84 E. Randolph St., Chicago, Ill.)

19–22. Metallurgy of Plutonium—session on nuclear fuels, intern. symp., Grenoble, France. (Société Française de Métallurgie, 25, rue de Clichy, Paris, France.)

20–22. Manned Space Stations, Inst. of the Aeronautical Sciences symp., Los Angeles, Calif. (E. Levin, Rand Corp., 1700 Main St., Santa Monica, Calif.)

20–22. Southwestern Inst. of Radio Engineers, 12th annual, Houston, Tex. (H. E. Childers, College of Medicine, Baylor Univ., Waco, Tex.)

20–23. National Council of Teachers of Mathematics, Ann Arbor, Mich. (M. H. Ahrendt, 1201 16 St., NW, Washington 6.)

20–24. Congress of Gastroenterology, 6th intern., Leyden and Noordwijk aan Zee, Netherlands. (C. Schreuder, 16, Lange Voorhout, The Hague, Netherlands.)

20–24. Microbal Reactions in Marine Environments, symp., Chicago, Ill. (C. H. Oppenheimer, Inst. of Marine Science, Port Aransas, Tex.)

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of Box Number counts as 10 additional words. Payment in advance is required. Positions Open, $33 per inch or fraction thereof. No charge for box number.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below—no charge for Box Number. Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$33.00 per inch
4 times in 1 year	30.00 per inch
7 times in 1 year	28.00 per inch
13 times in 1 year	27.00 per inch
26 times in 1 year	26.00 per inch
52 times in 1 year	25.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

FELLOWSHIPS

Announcing Unversity of Louisville Predoctoral Fellowships in Biochemistry for 1960–1961. Stipends $1800–$2200 annually, tax-free, tuition paid. Dependency and travel allowances as required. Applications should be submitted by **1 March.** Write Chairman, Department of Biochemistry, University of Louisville School of Medicine, 101 West Chestnut Street, Louisville 2, Kentucky, for application. 1/22

POSITIONS WANTED

(a) **Young Biochemist**, M.S. degree, nutrition and cancer research experience; available for research appointment. (b) **Anatomy Ph.D.**, experience in anatomy, physiology, pharmacology teaching, research on fat and cholesterol studies; prefers industrial research or academic appointment. S1-3 Medical Bureau, Inc., Science Division, Burneice Larson, President, 900 North Michigan Avenue, Chicago. X

Information Scientist. Ph.D. in biological sciences, library science degree, pharmaceutical and agricultural industry experience. Box 6, SCIENCE. 1/15

POSITIONS OPEN

ATOMIC PERSONNEL, INC.

WRITE FOR APPLICATION OR SEND RESUME

•

Confidential Handling

Suit 1207-G,

A NATIONAL EMPLOYMENT AGENCY for the NUCLEAR FIELD

•

NO CHARGE TO INDIVIDUALS

1518 Walnut St., Phila. 2, Pa.

Science Teachers, Librarians, Administrators urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue. $1. Yearly (12 issues) membership, $5. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

POSITIONS OPEN

(a) **Bacteriologist**; Ph.D. also trained in virology and tissue culture; M.S. considered to head department, state-approved laboratory, 100-bed general hospital; to $8000; New England resort location. (b) **Biochemist**; Ph.D., interested in molecular biology, experienced tissue culture or virology; principal studies nucleic acid metabolism, structure, function; to $9000; southwestern university medical school, research institute. (c) **Bacteriologist**; Ph.D., equivalent, to head bacteriology, parasitology, serology, responsible to attending pathologist for work of six employees; 450-bed general teaching hospital; to $9000; East. (d) **Biochemist**; Ph.D. experienced in coagulation; to train inplant visitors in coagulation, related problems, seminars, related areas; prominent eastern research, pharmacological house; $10,000. Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

(a) **Clinical Biochemist** with advanced degree to supervise department with 10 technicians in expanding hospital; around $10,000 year; also **Research Biochemist**, Ph.D., to assist with routine chemistries but primarily for research; $9000–$12,000 year; East. (b) **Assistant Professor of Biology** to teach botany, zoology, parasitology, reporting September; also **Visiting Biology Professor** for summer term; Southwest. (c) **Senior Physiologist** qualified in pharmacology or biochemistry; interest in CNS or toxicology preferred; around $10,000 year; pharmaceutical firm, Midwest. (d) **Plant Physiology Research Associate** with radioisotope experience; university in Midwest. (e) **Endocrinologist** with steroid background to organize new research group for leading pharmaceutical company, Midwest. (f) **Physiologist**, highly qualified for academic teaching and research in expanding medical school; up to $12,000 year; very desirable location. (Please write for details; also many other positions available through our nation-wide service.) S1-3 Medical Bureau, Inc. Science Division, Burneice Larson, President, 900 North Michigan Avenue, Chicago. X

Staff Assistant in Nomenclature

COUNCIL ON DRUGS

Master's degree or equivalent in chemistry, to assume responsibility for negotiating Council consideration of nonproprietary (generic) names for new chemical or biological agents to be used as drugs, including maintenance of a file of chemical information on all such terminology. Experience or strong interest in organic chemical and/or drug nomenclature desirable. Salary commensurate with background and experience. Send full résumé to

Dr. H. D. Kautz, Secretary
COUNCIL ON DRUGS
AMERICAN MEDICAL ASSOCIATION
535 North Dearborn Street
Chicago 10, Ill.

RADIOISOTOPES IN RESEARCH

Long a leader in the production of radiopharmaceuticals, Abbott Laboratories seeks an experienced imaginative scientist to direct its central radioisotope research laboratories and to collaborate in the application of isotopic tracer techniques throughout its Scientific Division. This is an established function with newly constructed facilities and is distinct from radiopharmaceutical manufacture.

Applicant should have a Ph.D. degree in either the physical or biological sciences and have demonstrated administrative ability. Age, 30-45. Experience in the handling and use of isotopes in biological studies is a prerequsite.

Reply to: Dr. K. J. Frederick, Physical Chemistry Research
Abbott Laboratories, North Chicago, Illinois

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$33.00 per inch
4 times in 1 year	30.00 per inch
7 times in 1 year	28.00 per inch
13 times in 1 year	27.00 per inch
26 times in 1 year	26.00 per inch
52 times in 1 year	25.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

SCIENTIFIC JOURNALS WANTED

Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. **Abrahams Magazine Service, N. Y. 3, N. Y.**

PROFESSIONAL SERVICES

HISTOLOGY
for
Industry and Research
GEORGE L. ROZSA, M.D.
143 Linwood Ave. Buffalo 9, New York
GRant 7165

PATHWAY RESEARCH LABORATORIES, Inc.

Fluorescent Antibody Reagents and Antisera

Contract Research and Consulting in Microbiology and Biochemistry

Write for our free brochure

11102 South Artesian Avenue
Chicago 43, Illinois

SUPPLIES AND EQUIPMENT

YOU NEED THIS **FREE** CATALOG FOR YOUR FILES

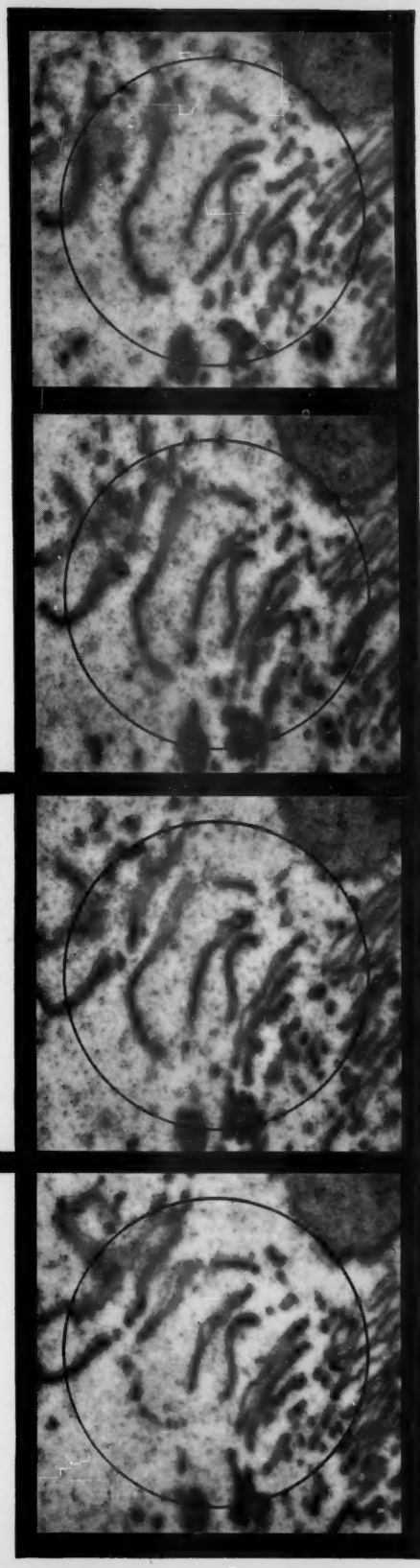
Serums, antiserums and bloods of all kinds for technicians and tissue culture laboratories. No salesman will call.

COLORADO SERUM CO.
4950 York St. • MAin 3-5373 • Denver 16, Colo.

SWISS MICE

BACTERIOLOGICAL AND GROSS TISSUE STUDY TECHNIQUES USED IN OUR QUALITY CONTROL

HUNTINGDON FARMS, INC.
2548 NORTH 27th ST. PHILA. 32, PA.



SERVALL®

SECTIONING FOR ELECTRON AND LIGHT MICROSCOPY?

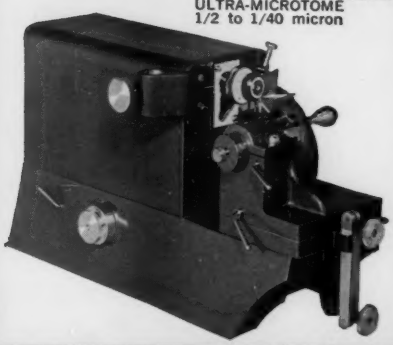
The micrographs shown here are of four serial sections from the same region of a rat parotid cell. The sections were cut with a SERVALL "Porter-Blum" Ultra-Microtome. Serial sectioning of such uniform thinness and quality makes it possible to follow the long, slender structures of the cytoplasm (as within the circles) successively and determine that they are lamellar and vesicular in form, rather than filamentous or tubular as might be adjudged if but a single section were observed, or if true uniformity of successive sections were not obtainable. Quite obviously the SERVALL "Porter-Blum" Ultra-Microtome is a high-precision instrument, but nevertheless it is simple to operate. It has manual advancement, a dial-type thickness selector, a unique specimen by-pass slide that enables the operator to cut thin and thick sections alternately, and many other features that have earned it the appellation: "The standard in its field." Illustrated literature and prices upon request for BULLETIN SC-15.

Diamond Knife and Holder for harder materials, Microscopes, and other accessories available from Ivan Sorvall, Inc.

THIN SECTIONING & ASSOCIATED TECHNICS FOR ELECTRON MICROSCOPY—recently published—an extremely useful handbook for all engaged in microtomy and related work. From Ivan Sorvall, Inc. at $2.00 per copy.

80 pp. Illus.

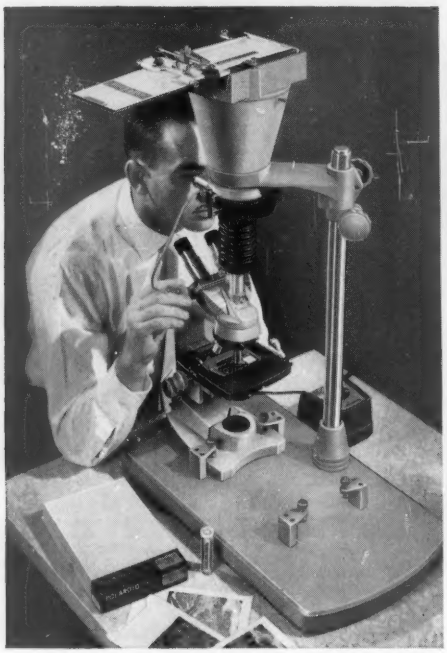
SERVALL "PORTER-BLUM" ULTRA-MICROTOME 1/2 to 1/40 micron



Ivan Sorvall, Inc.
NORWALK • CONNECTICUT

NOW! Snap it... See it...

IN BIG POLAROID LAND 4" x 5" PRINTS



AO Spencer Photomicrographs
. . . just 60 seconds from snap to finish

Now your AO Photomicrographic Camera can be equipped with the new Polaroid Land Film Holder to give you big 4"x5" finished, glossy prints . . . ready for your files . . . in just 60 seconds. A coupled visual and photographic system allows you to shoot exactly what you see . . . instantly and effortlessly. Processing of the picture takes place right in Polaroid's 4"x5" Holder, thus possible errors in exposure, illumination or focus can be rectified immediately.

If you prefer, you have a wide choice of 5 other readily interchangeable camera backs; the Polaroid Land Camera Back for roll film, paper prints and transparencies, 4" x 5" fixed back, 4" x 5" Graflok back, 35mm back and Bantam (roll film) back. You choose the camera back and film best suited to your specific requirements.

This new "Big-Size" 4" x 5" Polaroid Film Holder is available from your industrial photographic supplier.

Here, the No. 682G Camera being used with the AO Spencer Series 4 Microstar proves an ideal combination. The built-in base illuminator provides convenient Koehler-type illumination. You select specimen area and do all preliminary focusing through binocular portion of trinocular body . . . focus critically with the telescopic eyepiece.

The sturdy vertical pillar, the easily adjustable camera support, the camera back and the Microstar all combine to provide a compact unit in precise, rigid alignment. Successful photomicrography becomes a "snap".

Try it and see for yourself. Your AO Representative will be happy to arrange a convincing demonstration for you.

SPENCER

American Optical Company

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Dept. A-3

☐ Please send me Brochure SB682 describing the entire line of AO Spencer Photomicrographic Cameras.

☐ Please send me Brochure SB124 describing the new Microstar line.

Name _____

Address _____

City _____ Zone ____ State _____